VOL. XII. [MAY, 1890.] No. 5.

AMERICAN

CHEMICAL JOURNAL.

Contributions from the Chemical Laboratory of Harvard College.

LXVIII.—ON TETRABROMDINITROBENZOL.

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After it had been determined that the tribromdinitrobenzol, melting at 192°, reacted easily with a variety of substances, it seemed of interest to try similar experiments with a tetrabrom compound, and we selected for this purpose the tetrabromdinitrobenzol, melting at 228°, and describe in this paper the results of our work, which may be briefly summarised as follows. Tetrabromdinitrobenzol is not acted on by alcoholic ammonia in open vessels, but, if heated with it in a sealed tube, is converted into a yellow substance insoluble in all the common solvents, which seems to be the bromtriamidodinitrobenzol. With aniline the bromtrianilidodinitrobenzol, melting at 175°–176°, is formed. With sodium malonic ester it gives in the cold dibromdinitrophenylmalonic ester, melting point 89°, which possesses acid properties, forming a red sodium salt, and is converted by aniline into the bromanilidodinitrophenylmalonic ester, melting at 127°. The action of these reagents on the tetrabromdinitrobenzol is therefore similar to their behavior with tribromdinitrobenzol, the fourth atom of bromine remaining unaffected in all these reactions. We were prevented by want of time from trying to remove this fourth atom of bromine by reactions carried on at higher temperatures. We have studied also the reduction of the dibromdinitrophenylmalonic ester with tin and hydrochloric acid, and have obtained in this way the bromamidooxindol, $C_6H_2BrNH_2(CH_2CONH)$, melting at about 212°, and its chloride, $C_6H_2BrNH_2(CH_2CONH)HClH_2O$. We may add, that in preparing the tetrabromdinitrobenzol from somewhat impure tetrabrombenzol we obtained the as yet undescribed pentabromnitrobenzol, which melts at 248°, and on another occasion the hexabrombenzol.

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[1] Communicated by the authors, from the Proceedings of the American Academy of Arts and Sciences.

Preparation of Tetrabromdinitrobenzol.

Our starting point in the manufacture of the tetrabrombenzol was tribromaniline, which we prepared as follows. 60 grams of aniline were dissolved in dilute hydrochloric acid, and the solution having been made up to a volume of about three liters, a rapid stream of air saturated with bromine vapor was sucked through it by means of a Bunsen pump until the liquid assumed a distinct yellow color. The precipitate of tribromaniline was then removed by straining through cheese-cloth, washed with a stream of common water until free from acid, when the greater part of the water was squeezed out with a screw press and the product thoroughly dried on a steam radiator. In this way a quantitative yield of tribromaniline free from colored by-products was obtained at a much less expense of time and labor than by the method formerly in use.

To convert the tribromaniline into tetrabrombenzol we used the method of V. von Richter[1] slightly modified, which left nothing to be desired so far as the yield was concerned, when the process was successful; this, however, was not always the case, as frequently the product was a substance melting in the neighborhood of 87°, from which tetrabrombenzol melting at 98° could be obtained only by repeated crystallisation from a mixture of alcohol and benzol, and even then not in large quantity.[2] In spite of many experiments, we have not succeeded in determining with certainty the conditions under which this mixture was formed, or the nature of the impurity which it contained, and can give only the conditions which usually gave a good result. 25 grams of the tribromaniline were dissolved in a small quantity of glacial acetic acid with the aid of heat, and, after the solution had cooled, a concentrated aqueous solution of hydrobromic acid[1] was added, which threw down a precipitate of tribromaniline bromide; the mixture was stirred vigorously, and, disregarding the precipitate, a concentrated aqueous solution of about the theoretical amount of sodic nitrite added in small portions, keeping the solution cool by immersing the beaker containing it in cold water; the beaker was then warmed gently on the water-bath, and solid sodic nitrite added in small pieces until the proportion of the total sodic nitrite to the tribromaniline was three molecules to one (this very large excess of sodic nitrite being found necessary to complete the reaction). The liquid on cooling deposited a tarry mass, which was extracted repeatedly with small quantities of hot alcohol until it was converted into crystals (melting at about 95°). An additional amount of these crystals was obtained by pouring into water the red liquid from which the tar had been deposited, but this amount was not large. The product, after purification by one or two crystallisations from hot alcohol, showed a yield of from 89 to 93 per cent. of the theoretical.

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[1] Ber. d. chem. Gesell. 8, 1428.

[2] Owing to this uncertainty in our modification of Von Richter's process, we made two attempts to use Sandmeyer's method, but encountered such difficulties in applying it to tribromaniline that we decided it was easier to prepare our material by Von Richter's process than to overcome these difficulties.

To convert the tetrabrombenzol into tetrabromdinitrobenzol, 10 grams of it were dissolved with the aid of heat in nitric acid of specific gravity 1.52, prepared in the laboratory from nitre and sulphuric acid; then the same volume of strong sulphuric acid was added, about 200 cc. of the mixture of the two acids being used, and, after standing in the cold for ten minutes, the whole was boiled for about an hour in a flask closed with a glass bulb. If the tetrabrombenzol was sufficiently pure there was little foaming and no violent action, and on cooling a white crystalline solid separated, which was nearly pure tetrabromdinitrobenzol, and, after crystallisation from benzol with a little alcohol, or from chloroform, showed the right melting point 228°.[2]

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[1] An attempt to substitute potassic bromide and sulphuric acid for hydrobromic acid gave a much poorer yield; less than 50 per cent. instead of 90.

[2] One of us and J. F. Wing (this Journal **10**, 291 (1883), some years ago obtained tetrabromdinitrobenzol as a secondary product in the manufacture of tribromtrinitrobenzol, but we were unable to raise its melting point above 224°; this was ascribed at the time to the presence of a little tribromtri- (or di-) nitrobenzol, an opinion which is confirmed by the fact mentioned above that tetrabromdinitrobenzol prepared by us according to the usual method showed the melting point 228° given by Von Richter (Ber. d. chem. Gesell. 1875, p. 1427). The difficulty in removing the tribrom compound can be accounted for by supposing that it forms the addition-product observed by one of us and G. D. Moore (Ber. d. chem. Gesell. 1888, p. 1707), or an analogous one with the trinitro compound.

If, on the other hand, a tetrabrombenzol was used containing some of the impurity already mentioned, which, when present in quantity, lowered the melting point to the neighborhood of 87°, the action was violent, the boiling being accompanied by much foaming, the product was often oily, and, after most of the solid had been precipitated by water, the aqueous liquid contained decomposition-products, as was shown by the blackish precipitate formed in it on the addition of sodic carbonate. The main product in this case was a mixture of the tetrabromdinitrobenzol and another substance, which was obtained by treatment with aniline or sodium malonic ester, and subsequent separation of the derivative of the tetrabromdinitrobenzol by crystallisation out of alcohol from the unaltered second product, which was then purified by crystallisation from boiling alcohol, or better, chloroform, until it showed the constant melting point 248°, when, after drying at 100°, it was analysed with the following results:

I. 0.1711 gram of the substance gave on combustion 0.0855 gram of carbonic dioxide and 0.0151 gram of water.

II. 0.2100 gram of the substance gave 0.1075 gram of carbonic dioxide and 0.0103 gram of water.

III. 0.1846 gram of the substance gave 3.5 cc. of nitrogen at a temperature of 17° and a pressure of 773 mm.

IV. 0.1881 gram of the substance gave, according to the method of Carius, 0.3418 gram of argentic bromide.

	Calculated for $C_6Br_5NO_2$.	Found.			
		I.	II.	III.	IV.
Carbon	13.90	13.63	13.96	...	...
Hydrogen	0.00	0.98	0.54	...	...
Nitrogen	2.70	...	...	2.24	...
Bromine	77.23	...	...	...	77.34

There can be no doubt, therefore, that this is the as yet undescribed pentabromnitrobenzol.

Properties.—The pentabromnitrobenzol crystallises in very slender little white needles which melt at 248°. The substance is essentially insoluble in water or ligroine; nearly insoluble in cold ethyl or methyl alcohol, more soluble when hot, but still sparingly; the solubility in glacial acetic acid or acetone is similar, except that it is much more soluble in either of these solvents when hot than it is in alcohol; readily soluble in hot benzol or chloroform; very soluble in ether or carbonic disulphide.

Although pentabromnitrobenzol was the usual impurity, on one occasion a different product was obtained, which consisted of small needles melting, after crystallisation from benzol, at about 312°, essentially insoluble in alcohol or sodic hydrate, and containing no nitrogen. We inferred therefore that this was the hexabrombenzol, which is said to melt above 315° and to be almost insoluble in boiling alcohol, and this inference was proved to be correct by the following analysis:

0.1303 gram of the substance gave, by the method of Carius, 0.2666 gram of argentic bromide.

	Calculated for C_6Br_6.	Found.
Bromine	86.96	87.10

Preliminary Experiments.

After the tetrabromdinitrobenzol had been prepared, the following experiments were tried to determine the ease with which it reacted with various substances.

As has been stated in an earlier paper, alcoholic ammonia has no action on tetrabromdinitrobenzol in the cold, or even if the substances are heated together in open vessels. If, however, the mixture is heated to 100° in a sealed tube for four or more hours, a reaction takes place, giving an orange precipitate and a red alcoholic solution in addition to some unaltered tetrabromdinitrobenzol. The orange insoluble substance was undoubtedly the bromtriamidodinitrobenzol, but, as it was insoluble in all the common solvents, we could only try to purify it by washing, and even after repeated treatment with water, alcohol, chloroform and benzol, were unable to obtain a substance giving constant results on analysis; the bromine varied in different samples from 25.34 to 29.07 per cent., the amount required by the formula,

$$C_6Br(NO_2)_2(NH_2)_3,$$

being 27.39. Although it is probable that further work on this substance would have enabled us to find a method of purifying it, we did not think it worth while to sacrifice the time, as these analyses show that the reaction has run in the same way as that between tribromdinitrobenzol and alcoholic ammonia, and nothing of interest was likely to be found in its investigation. The substance is an orange-yellow powder, insoluble in all the common solvents, and not melting even at 285°. The alcoholic filtrate contained a yellow substance melting at 185° in the crude state, but we did not obtain enough of it for investigation. With aniline a more favorable result was obtained, which is described fully in the next section of this paper.

When boiled with potassic sulphocyanate in alcoholic solution in a flask with a return condenser, there was very little action, but, if amyl alcohol was substituted for ethyl alcohol, so that the action would take place at a higher temperature, a dark red substance was formed, insoluble in all the common solvents. In this respect the tetrabromdinitrobenzol behaved exactly like the tribromdinitrobenzol, and, as it had been found impossible to purify the corresponding product from the tribrom compound, we did not think it worth while to continue work in this direction.

With sodium malonic ester or sodium acetacetic ester it behaves like the tribromdinitrobenzol. The action with sodium malonic ester is described in detail later in this paper.

In all the derivatives of tetrabromdinitrobenzol which were analysed it was found that only three of the atoms of bromine had been attacked. We had hoped to try some experiments at higher temperatures for the purpose of replacing the fourth atom of bromine, but the work described in this paper has taken so much time that we have been unable to take up this branch of the subject.

Bromdinitrotrianilidobenzol, $C_6Br(NO_2)_2(C_6H_5NH)_3$.

To prepare this substance tetrabromdinitrobenzol was heated with aniline in the proportion of one molecule of the former to a little more than six of the base. Convenient amounts were 7 grams of tetrabromdinitrobenzol to 8.3 grams of aniline. When the mixture was heated on the water-bath the solid dissolved after some time, the solution being accompanied by a change of color from yellow to bright red, and on cooling the whole solidified to a mass of red needles; but in order to get even a tolerable yield of the new substance the heating on the water-bath must be continued for at least four to six hours, and then it is not by any means complete. A higher heat than the water-bath should not be used, as then the mixture shows a tendency to pass into a purplish coloring matter, resembling impure rosaniline in appearance and similar to the substance obtained in the same way from tribromtrinitrobenzol,[1] and like that undoubtedly produced by the nitro groups taking part in the reaction. If the reaction had run properly, the product consisted of a viscous or crystalline mass of the color of red lead, from which in the first place the aniline bromide and excess of aniline were removed by washing with water containing a little hydrochloric acid, leaving a brick-red powder. The purification was completed by crystallisation from alcohol, and afterward from a mixture of alcohol and chloroform, until it showed the constant melting point 175°–176°. If there was difficulty in obtaining crystals of the proper melting point, it was found advisable to warm the substance again with aniline for two or more hours, and then purify again in the manner just described. In addition to unaltered tetrabromdinitrobenzol a small amount of an impurity was found, which melted in the crude state between 120° and 140°, but we did not succeed in isolating a substance fit for analysis from it. The main product, when pure, was dried at 100°, and analysed with the following results:

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[1] This Journal **10**, 291 (1888).

I. 0.1667 gram of the substance gave 20.4 cc. of nitrogen at a temperature of 25° and a pressure of 768.4 mm.

II. 0.1624 gram of the substance gave, by the method of Carius, 0.0578 gram of argentic bromide.

	Calculated for $C_6Br(NO_2)_2(C_6H_5NH)_3$.	Found.	
		I.	II.
Nitrogen	13.46	13.81	...
Bromine	15.38	...	15.15

Properties.—Bromtrianilidodinitrobenzol forms a brilliant but rather dark red crystalline powder, which, when examined with the microscope, consists of crystals of two forms, rather short prisms terminated by an obtuse angle, and thick groups shaped like an hour-glass and made up of short prisms which seem to have the same terminal angles as those which are not in groups; the groups are rather darker in color than the free prisms, but this is probably due to their being thicker. When crystallised from hot alcohol, instead of the usual mixture of alcohol and chloroform, characteristic forms like sheaves were obtained, also a small quantity of red, nearly square plates. It melts at 175°–176°; is essentially insoluble in ligroine, or in water either cold or boiling; very slightly soluble in cold alcohol, more soluble in hot; more soluble in methyl than in ethyl alcohol; slightly soluble in cold ether, freely in hot; moderately soluble in glacial acetic acid;

freely soluble in benzol, chloroform, or carbonic disulphide; very freely in acetone. The best solvent for it is a mixture of alcohol and chloroform, as it tends to separate in a viscous state from the solution in chloroform alone. Strong sulphuric acid dissolves it slightly, forming a pale yellow solution. Strong nitric acid acts in the same way, but less energetically; fuming nitric acid acts upon it violently even in the cold. Hydrochloric acid has no action either hot or cold. The absence of basic properties is accounted for by the presence of the two nitro groups. We tried also the action of sodic hydrate, as certain nitroamido compounds possess weak acid properties,—for instance, the trinitrotoluidine of Nölting and Salis,[1]—but found that it produced no effect.

Dibromdinitrophenylmalonic Ester,
$C_6HBr_2(NO_2)_2CH(COOC_2H_5)_2$.

This substance was prepared by acting on one molecule of tetrabromdinitrobenzol with about four molecules of sodium malonic ester, as follows: 15 grams of tetrabromdinitrobenzol dissolved in about 20–30 cc. of benzol were mixed with 20 grams of malonic ester previously converted into sodium malonic ester by treatment with the sodic ethylate made from 3 grams of sodium dissolved in 100 to 150 cc. of absolute alcohol. The action began at once, as shown by the appearance of a dark red color and a considerable evolution of heat, so that the flask became too hot to hold in the hand with comfort; in this respect it differed from that with the tribromdinitrobenzol, as, although in that case the red color appeared at once, no perceptible rise of temperature was observed in any part of the reaction. To make certain that the reaction had run as far as possible, the mixture was allowed to stand in the cold for three or four days. At the end of this time the product was diluted with about half a liter of water, and the benzol separated from the red aqueous solution of the salt of the new substance. Upon adding dilute sulphuric acid to this aqueous solution, the new substance was precipitated, and after washing with water was purified by crystallisation from alcohol until it showed the constant melting point 89°, when it was dried *in vacuo* for analysis. The benzol solution, which separated on the addition of water, was evaporated to dryness, and the residue, consisting of the new substance, a little unaltered tetrabromdinitrobenzol, and an oil, after being freed from the oil on the pump, was treated with alcohol, in which the tetrabrom compound is essentially insoluble, and the small amount of the new substance thus obtained was added to that from the aqueous solution.

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[1] Ber. d. chem. Gesell. **15**, 1864.

I. 0.2183 gram of the substance gave on combustion 0.2568 gram of carbonic dioxide and 0.0528 gram of water.

II. 0.2144 gram of the substance gave 11.4 cc. of nitrogen at a temperature of 23.1° and a pressure of 763.4 mm.

III. 0.2372 gram of the substance gave, by the method of Carius, 0.1833 gram of argentic bromide.

	Calculated for $C_6HBr_2(NO_2)_2CH(CO_2C_2H_5)_2$.	Found. I.	II.	III.
Carbon	32.23	32.07	...	...
Hydrogen	2.48	2.69	...	...
Nitrogen	5.78	...	6.02	...
Bromine	33.06	...	...	32.91

The yield of dibromdinitrophenylmalonic ester was very satisfactory. On one occasion 5 grams of tetrabromdinitrobenzol gave 4 grams of the dibromdinitrophenylmalonic ester, instead of the 5 grams required by the theory, that is, 80 per cent. of the theoretical yield. This large yield proves conclusively that dibromdinitrophenylmalonic ester is the only aromatic product of the reaction, a point which before this observation seemed somewhat doubtful in the analogous preparations described in other papers from this laboratory, as in them the yield rose but little above 50 per cent. of the theory.

The amount of bromine separated as bromide of sodium in the preparation of the substance was determined in two cases, as follows:

I. 5 grams of tetrabromdinitrobenzol yielded 3.707 grams of argentic bromide, corresponding to 1.578 gram of bromine.

II. 5 grams of tetrabromdinitrobenzol yielded 3.631 grams of argentic bromide, corresponding to 1.545 gram of bromine.

The theoretical yield, if two of the atoms of bromine had been removed, would be 1.653 gram.

Percentage of bromine found as bromide of sodium:

I.	II.
95.43	93.48

From these numbers it appears that essentially all the bromine is removed as sodic bromide.

The oil which formed the secondary product of the reaction was not investigated further, as from the composition of the ester, and the fact that all the bromine appeared as sodic bromide, there could be no question that the nature of this action is the same as that with the tribrom compounds; and in those cases[1] the study of the oils has shown conclusively the mode of formation of the substances. There can be no doubt, therefore, that the reactions which take place in this case should be written as follows:

$$\begin{aligned}
&C_6Br_4(NO_2)_2 + 2\,CHNa(COOC_2H_5)_2 = \\
&\quad NaBr + C_6Br_3(NO_2)_2CH(COOC_2H_5)_2 + CHNa(COOC_2H_5)_2 = \\
&\quad C_6Br_3(NO_2)_2CNa(COOC_2H_5)_2 + CH_2(COOC_2H_5)_2 + NaBr = \\
&\quad C_6HBr_2(NO_2)_2CNa(COOC_2H_5)_2 + CHBr(COOC_2H_5)_2 + NaBr.
\end{aligned}$$

The brommalonic ester being converted afterward into tartronic or acetylentetracarbonic ester.

Properties.—The dibromdinitrophenylmalonic ester crystallises from alcohol usually in slightly yellow to colorless needles, which unite into groups like pompons if the solution is dilute; seen under the microscope they consist of rather long rhombic plates with a decidedly acute angle about six times as long as their breadth, or even slenderer, either free or in radiating groups, the crystals branching so as to give the effect of being arranged in curved lines. When less well developed the groups are made up of fine needles very much branched, like certain feathery seaweeds. From the oil which forms the secondary product in its preparation the substance crystallises in flattened prisms, often two centimeters in length, arranged in slightly radiating groups. The melting point is 89°. It is essentially insoluble in water or ligroine, slightly soluble in cold, freely in hot methyl or ethyl alcohol; freely soluble in carbonic disulphide, glacial acetic acid, or acetone; very freely in ether, benzol, or chloroform. Strong sulphuric acid has little, if any, action on it in the cold, but dissolves it slightly without change of color when hot. Strong nitric acid also seems not to act upon it in the cold, but, when warmed with it, turns yellow and imparts a yellow color to the drops of the melted substance which swim on its surface. Hydrochloric acid does not seem to act upon it in open vessels, either cold or warm, although from analogy with the corresponding monobrom compound it is fair to suppose that it would decompose it if the two substances were heated to 150° in a sealed tube.

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[1] This Journal **11**, 544 (1889); **12**, 14 (1890).

The dibromdinitrophenylmalonic ester has well marked acid properties, as was to be expected from the fact that one of its atoms of hydrogen is attached to a carbon atom in direct contact with two carboxylester radicals and a dinitrophenyl. An excess of sodic hydrate in aqueous solution has but little action on the solid, turning it pale red ; if, however, a drop of alcohol is added it turns a very dark red at once, and the salt begins to dissolve. Potassic carbonate acts in much the same way. Acid sodic carbonate in aqueous solution has no effect, but if alcohol is added there is a slight action, shown by formation of a little of the red salt. Ammonic hydrate in aqueous solution has but little action, but turns red if a little alcohol is added, and upon warming this mixture a deep brownish red solution is obtained, which smells strongly of ammonia, even if an excess of the ester is used in making it. It seems to be decomposed by heating, or by exposure to the air, so that the ammonium salt must be a very unstable substance. The solution of the ammonium salt made with an excess of the ester (but still smelling of ammonia) was treated with various reagents, and gave the following characteristic precipitates:

With a salt of *magnesium*, *calcium*, *strontium*, or *barium*, very heavy pale red flocks.

With a *zinc* salt, pale yellow flocks.

With a salt of *manganese*, *cobalt*, or *nickel*, pale red flocks.

With a *ferric* salt, pale brownish purple.

With a *cupric* salt, bright yellow.

With salts of *mercury*, pale red.

With a *cadmium* salt, reddish yellow.

With a *lead* salt, whitish red.

With a *silver* salt, pale orange.

Strong nitric acid gave with the salts a white precipitate, probably the unaltered ester. In this respect it differs from bromtrinitrophenylmalonic ester.

Bromanilidodinitrophenylmalonic Ester,
$C_6HBr(C_6H_5NH)(NO_2)_2CH(COOC_2H_5)_2$.

This substance was made by adding aniline to the dibromdinitrophenylmalonic ester in the proportion of a little more than two molecules of the base to one of the ester. The reaction began in the cold, but was brought to an end by warming the mixture for a short time on the water-bath. The product, after washing with water, to which a little hydrochloric acid was added to remove aniline bromide and the excess of aniline, was crystallised from hot alcohol until it showed the constant melting point 127°, when it was dried at 100°, and analysed with the following result:

0.2003 gram of the substance gave 14.85 cc. of nitrogen at a temperature of 20.5° and a pressure of 762 mm.

	Calculated for $C_6HBr(C_6H_5NH)(NO_2)_2CH(CO_2C_2H_5)_2$.	Found.
Nitrogen	8.47	8.49

Properties.—The bromanilidodinitrophenylmalonic ester crystallises from alcohol in bright red needles, which under the microscope are seen to be slender prisms terminated usually by two planes, less commonly by one, and seeming to belong to the monoclinic system. The substance melts at 127°, and is essentially insoluble in cold water, very sparingly soluble in boiling water, as shown by the faint yellow color imparted to the liquid; insoluble in ligroine; very slightly soluble in cold ethyl or methyl alcohol, more freely in either of these solvents when hot; slightly soluble in ether; soluble in benzol or glacial acetic acid; freely soluble in chloroform, carbonic disulphide, or acetone. Strong sulphuric acid dissolves it slightly, forming a yellowish solution; the solubility did not seem to be increased by heat. Strong nitric acid dissolved it rather more freely than sulphuric acid, and the solubility was increased by heat. Strong hydrochloric acid had no action upon it, although it is probable that long heating in a sealed tube with this acid would have decomposed it in the way described[1] under the bromdinitrophenylmalonic ester.

The acid properties of this substance have been much weakened by the replacement of bromine by the basic aniline radical C_6H_5NH, but that they still exist is shown by the following observations. Sodic hydrate in aqueous solution has no action on the solid, but on the addition of a little alcohol a dark red solution of the salt is formed; sodic carbonate in aqueous solution produces no effect, but on the addition of alcohol a very slight red coloration appears; acid sodic carbonate produces no effect even in presence of alcohol. Ammonic hydrate in aqueous solution does not dissolve the solid substance, and, even if alcohol is added, the action is very slight; if, however, the mixture of aqueous ammonic hydrate, alcohol, and the solid is warmed on the water-bath, a dark red solution is obtained, which smells of ammonia, even if a large excess of the ester is used. The behavior of such a solution with various reagents was studied with the following results:

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[1] This Journal **11**, 548 (1889).

Salts of *magnesium*, *calcium*, *strontium*, or *barium* gave rusty brown precipitates.

The salts of the heavy metals gave yellow precipitates, except where the color was modified by the excess of ammonia, which could not be removed from the solution of the salt.

Reduction of Dibromdinitrophenylmalonic Ester.

The investigation of this subject interested us especially, because it seemed probable that the diamidophenylmalonic or acetic acid, which would be the first product of the reaction, would lose water and become converted into an amidooxindol, especially since Bischoff[1] obtained from the reduction of his orthonitrobenzoylmalonic ester α-γ-dihydroxychinoline. As with zinc and alcoholic hydrochloric acid, or with zinc dust and acetic acid, he obtained more complex products, some of which it was almost impossible to purify, we decided to try first the action of tin and hydrochloric acid with alcohol upon our dibromdinitrophenylmalonic ester, and for this purpose proceeded as follows: Two grams of the dibromdinitrophenylmalonic ester were mixed with alcohol, strong hydrochloric acid, and tin, a piece of platinum foil being used to accelerate the action, and the mixture was kept upon a steam radiator at a temperature of from 50°–70° until the whole of the malonic compound had disappeared, which usually happened in an hour and a half. The clear solution was poured off from the excess of tin, and, after evaporation to dryness, dissolved again in water, and freed from tin with sulphuretted hydrogen; upon concentrating the filtrate long needles separated, which varied in color from brown to nearly white. By further concentration of the mother-liquors a fresh crop of crystals was obtained, and the precipitate of sulphide of tin must be boiled out several times with water, as the reduction-product is but slightly soluble. As the substance seemed to be decomposed to a certain extent by our attempts to purify it by crystallisation, we analysed some of it without further purification, while other samples were crystallised once more from hot water, allowing the solution to cool *in vacuo* to avoid oxidation by the air. It was dried *in vacuo*, and analysed with the following results:

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[1] Ann. Chem. **251**, 364.

I. 0.0977 gram of the substance gave on combustion 0.1224 gram of carbonic dioxide and 0.0434 gram of water.

II. 0.3108 gram gave on combustion 0.3869 gram of carbonic dioxide and 0.1128 gram of water.

III. 0.1113 gram of the substance gave 9.8 cc. of nitrogen at a temperature of 25.5° and a pressure of 763 mm.

IV. 0.1010 gram of the substance treated with argentic nitrate and the precipitate washed with nitric acid and water gave 0.0498 gram of argentic chloride.

V. 0.4762 gram gave 0.2461 gram of argentic chloride.

	Found.				
	I.	II.	III.	IV.	V.
Carbon	34.17	33.93	...	...	...
Hydrogen	4.93	4.03	...	...	...
Nitrogen	...	...	9.84	...	...
Chlorine	...	...	...	12.19	12.77

The free base corresponding to this chloride was next prepared by adding ammonic hydrate to a strong solution of it, when a white precipitate swimming in a dark green liquid was obtained. It was purified by washing with cold water, in which it is as good as insoluble, until the wash water gave no test for a chloride, then dried *in vacuo*, and analysed with the following results:

I. 0.1690 gram of the substance gave on combustion 0.2587 gram of carbonic dioxide and 0.0580 gram of water.

II. 0.2021 gram of the substance gave 23.7 cc. of nitrogen at a temperature of 24.5° and a pressure of 768.5 mm.

	Found.	
	I.	II.
Carbon	41.75	...
Hydrogen	3.81	...
Nitrogen	...	13.28

The following comparison shows that the numbers obtained from the analyses of the chloride correspond to those calculated for the formula $C_8H_9BrN_2O_2HCl$ (with the exception of the hydrogen,[1] which was undoubtedly brought too high by the passing over of a part of the halogen into the sulphuric acid tube).

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[1] The formula $C_8H_{11}BrN_2O_2HCl$ requires 4.23 per cent. of hydrogen, and is therefore distinctly too high for Analysis II, and the analysis of the "chloride of the free base" given later. The small amount of substance used in Analysis I makes the per cent. of hydrogen in it of no value.

	Calculated for $C_8H_9BrN_2O_2HCl$.	Found.	
Carbon	34.12	34.17	33.93
Hydrogen	3.55	4.93	4.03
Nitrogen	9.95	9.84	...
Chlorine	12.61	12.19	12.77

On the other hand, the numbers given by the analyses of the free base indicate a substance containing one molecule less of water.

	Calculated for $C_8H_7BrN_2O$.	Found.	Calculated for $C_8H_9BrN_2O_2$.
Carbon	42.30	41.75	39.17
Hydrogen	3.08	3.81	3.67
Nitrogen	12.34	13.28	11.43

The want of agreement between the percentages of hydrogen[1] is explained in the same way as in the analyses of the chloride. Otherwise the numbers come as near as could be expected, when it is remembered that the free base was so unstable that we did not dare to purify it except by washing, and that it gradually turned brown even when dry.

In order to harmonise these results and determine the nature of the substances we have found only three hypotheses.

First, and most obvious. The two substances belong to different classes, *i. e.* one is the chloride of the bromdiamidophenylacetic acid, $C_6H_2BrNH_3ClNH_2CH_2COOH$; the other is free bromamidooxindol, $C_6H_2BrNH_2(CH_2CONH)$.

If, on the other hand, the substances belong to the same class,—

Second. They are the bromamidooxindol and its chloride. In this case the chloride must contain one molecule of water of crystallisation.

Third. They are bromdiamidophenylacetic acid and its chloride. In this case our analyses of the free base are incorrect.

If the first of these explanations is the true one, the chloride made by adding hydrochloric acid to the free base would be the chloride of the bromamidooxindol, and therefore different from the original chloride of the bromdiamidophenylacetic acid. To settle this point, we set free the base with ammonic hydrate from a quantity of the original chloride, and, after washing until free from ammonic chloride, dissolved it in dilute hydrochloric acid and crystallised it from the slightly acid solution. The general habit of the crystals of the two chlorides (the original one and that made from the free base) was the same, but there were differences in the modifications on the ends of the prisms which made the identity of the two somewhat doubtful; we accordingly analysed the chloride made from the free base, with the following results:

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[1] The formula $C_8H_9BrN_2O$ requires 3.93 per cent. of hydrogen.

0.1853 gram of the substance gave on combustion 0.2328 gram of carbonic dioxide and 0.0678 gram of water.

	Calculated for $C_8H_7BrN_2OHCl$.	Calculated for $C_8H_9BrN_2O_2HCl$.	Found.	Analyses of Original Chloride.	
Carbon	36.43	34.12	34.26	34.17	33.93
Hydrogen	3.04	3.55	4.06	4.93	4.03

There can be no doubt, therefore, of the identity of the two chlorides, and the first explanation must be abandoned.

The second explanation requires that the chloride should contain one molecule of water of crystallisation. This point was tested by heating the chloride with the following result:

0.2517 gram of the chloride heated for 6 hours at first at 110°, later to 135°, lost 0.0024 gram.

	Calculated for $C_8H_7BrN_2OHClH_2O$.	Found.
Water	6.42	0.95

From this it appears that, if the chloride contains water of crystallisation, it does not lose it at 135°. The slight loss of only 2.4 mgrs. could be sufficiently accounted for by the decomposition of the salt which had turned dark gray on the surface, and for this reason too the heating could not be repeated at a higher temperature.

This result, unfavorable to the second explanation, necessitates the discussion of the third—that the free base is bromdiamidophenylacetic acid—which otherwise we should not have thought worthy of consideration. As has been already stated, the analyses of the free base do not agree with this explanation, and in order to adopt it we must assume that the substance had undergone a decomposition sufficient to raise the carbon 2.58 per cent., an assumption improbable in itself and not supported by the appearance of the preparation, which had only a slight dirty pink color. This we think is enough to condemn this third explanation, but we add the following considerations, all of which tell strongly in favor of the second and against the third explanation. (1) Gabriel and R. Meyer[1] by the reduction of dinitrophenylacetic acid with tin and hydrochloric acid obtained the paramidooxindol direct, and it does not seem possible that our bromdiamidophenylacetic acid, which differs from theirs only in containing an atom of bromine, should be so much more stable. (2) Our free base agrees fairly well in properties with the paramidooxindol of Gabriel and R. Meyer. Both are easily oxidised, soluble in hot water or in alcohol, slightly soluble in benzol or carbonic disulphide, the only difference being that our base is nearly insoluble in ether, whereas theirs is soluble in it. The melting points also stand about where we should expect, amidooxindol about 200°, our bromamidooxindol about 212°; in both cases there was so much blackening that the melting point could not be accurately determined. (3) Our base (or its chloride) gives the indol reaction, turning a piece of pine wood red if boiled with it and dilute sulphuric acid, or if the wood, after being saturated with a solution of the base, is soaked in strong hydrochloric acid. This seems to us conclusive. The color is rather dull, and appears only after some time; but the objection which might be urged against this argument on this account, that the bromdiamidophenylacetic acid was converted into the bromamidooxindol by treatment with the acids, has no weight, as in the preparation of the original chloride it was most thoroughly exposed to the action of strong hydrochloric acid, both hot and cold; and yet this chloride, as we have shown by the analyses, contained two atoms of hydrogen and one of oxygen more than is required by the chloride of the bromamidooxindol.

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[1] Ber. d. chem. Gesell. **14**, 832.

These arguments seem to us to prove conclusively that the two substances are bromamidooxindol $C_6H_2BrNH_2(CH_2CONH)$, and its chloride $C_6H_2BrNH_2(CH_2CONH)HCl.H_2O$, in spite of the fact that we could not drive off the water of crystallisation from the chloride even at 135°.

Properties of Bromamidooxindol, $C_6H_2BrNH_2(CH_2CONH)$.

As precipitated from its chloride it forms a heavy flocculent white precipitate, which, when examined with the microscope, is seen to be a felt of small white needles, often arranged in fagots or groups like an hour-glass; it is not very stable, changing to a dirty pink on exposure to the air, even when dry. The substance analysed melted at 212° with a good deal of blackening, but we do not place much reliance on this melting point, as the sample used was a good deal colored. It is almost insoluble in cold, soluble in hot water; soluble in hot alcohol; insoluble, or nearly so, in ether or chloroform; not freely soluble in benzol or carbonic disulphide, even when hot; freely soluble in hot glacial acetic acid. Sodic hydrate dissolves it, giving a pinkish or pale magenta solution; ammonic hydrate at first seems to have no action, but on standing the liquid and solid turn dark bluish green; potassic carbonate in aqueous solution does not dissolve it. It seems therefore to have the properties of a phenol. Neither picric acid in benzol solution, nor ferric chloride with an alcoholic solution of the base, produced any change of color. If some of the free base was boiled with dilute sulphuric acid and a piece of pine, the wood was turned a dull orange-red.

As to the constitution of this base it has been determined by work[1] done in this laboratory on the bromdinitrophenylmalonic ester that the nitro group, from which the amido group is formed, is in the para position to the carbon side-chain. The bromine is probably in the ortho position, since all our work with the tetrabromdinitrobenzol has shown that only three of its atoms of bromine can be replaced easily; and, as the compounds made from this substance are so closely analogous to those prepared from the tribromdinitrobenzol, it is fair to infer that the three symmetrical (meta) atoms of bromine are those which can be removed, and that the fourth more stable atom of bromine is the one in the unsymmetrical (ortho) position; the atom of bromine, therefore, which reduction takes away from the dibromdinitrophenylmalonic ester, would be that in the meta position, and the base would be accordingly *orthobromparamidooxindol.*

Properties of the Chloride of Bromamidooxindol, $C_6H_2BrNH_2(CH_2CONH)HClH_2O$.

When crystallised from water the substance forms needles, or prisms, sometimes as much as a centimeter long and a millimeter thick, which seem to belong to the monoclinic system, and usually have a yellowish color; we think, however, that this color is due to partial oxidation, and that the substance is white when pure. When examined with the microscope the prisms are found to be arranged in globular radiating groups, and are terminated usually by a single rhombic plane at a not very oblique angle to the long sides of the prism; sometimes a number of other modifying planes are observed, giving a sharp end to the prism. From alcohol it crystallises in branching needles set at a very acute angle to each other. It melts only at a very high temperature, probably above the range of the mercury thermometer. It is slightly soluble in cold water, freely in hot; soluble in alcohol; slightly soluble in cold benzol, chloroform, or glacial acetic acid, freely soluble in these solvents, when hot; almost insoluble in ether; very soluble in carbonic disulphide. The best solvent for the substance is boiling water. An excess of ammonic hydrate throws down from a concentrated solution a heavy precipitate of the free base, which is white, but the liquid turns dark green; potassic carbonate gives a similar precipitate, not soluble in an excess; sodic hydrate in small quantity gives a similar precipitate, but dissolves it when added in larger quantity, giving a reddish solution. It gives a dull orange-red indol reaction with pine wood.

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[1] This Journal **11**, 556 (1889).

LXIX. — GENERAL CONSIDERATIONS IN REGARD TO CERTAIN COMPOUNDS PREPARED FROM BROMNITROBENZOLS.[1]

BY C. LORING JACKSON.

Several compounds derived from various bromnitrobenzols have been described recently by me in conjunction with other chemists in a number of papers[2] from this laboratory, but in the course of the work certain general observations were made in regard to them which could not conveniently be introduced in the separate papers, and are therefore collected here.

The Action of Sodium Malonic (or Acetacetic) Ester on Certain Bromnitrobenzols.

The actions studied were the following:

Sodium Malonic Ester on
  Tribromtrinitrobenzol, $C_6Br_3(NO_2)_3$, melting point 285°.
  Tribromdinitrobenzol, $C_6HBr_3(NO_2)_2$, melting point 192°.
  Tetrabromdinitrobenzol, $C_6Br_4(NO_2)_2$, melting point 228°.
Sodium Acetacetic Ester on
  Tribromdinitrobenzol, $C_6HBr_3(NO_2)_2$, melting point 192°.

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[1] Communicated by the author, from the Proceedings of the American Academy of Arts and Sciences.

[2] This Journal **10**, 283; **11**, 93, 448, 541; **12**, 7, 164, 289.

In all these cases the action was essentially the same, and may be represented by the following reactions for tribromtrinitrobenzol:

$$\text{I. } C_6Br_3(NO_2)_3 + CHNa(COOC_2H_5)_2 = NaBr + C_6Br_2(NO_2)_3CH(COOC_2H_5)_2.$$

$$\text{II. } C_6Br_2(NO_2)_3CH(COOC_2H_5)_2 + CHNa(COOC_2H_5)_2 = C_6Br_2(NO_2)_3CNa(COOC_2H_5)_2 + CH_2(COOC_2H_5)_2.$$

$$\text{III. } C_6Br_2(NO_2)_3CNa(COOC_2H_5)_2 + CH_2(COOC_2H_5)_2 = C_6HBr(NO_2)_3CNa(COOC_2H_5)_2 + CHBr(COOC_2H_5)_2.$$

The formation of brommalonic ester in III, the only point in these reactions about which there was any doubt, was proved by the isolation of acetylentetracarbonic ester[1] or of tartronic acid[2] from the oily secondary product, as these substances could hardly have been formed otherwise than by the following reactions:

$$CHBr(COOC_2H_5)_2 + CHNa(COOC_2H_5)_2 = CHCH(COOC_2H_5)_4 + NaBr.$$

$$CHBr(COOC_2H_5)_2 + NaOH = CHOH(COOC_2H_5)_2 + NaBr.$$

Reactions I–III are given because they show more clearly what has taken place, but the discussion which follows does not depend on them alone, since the analyses of the products are sufficient to prove that in all the cases studied the action has consisted in the replacement of one atom of bromine by the malonic ester radical, and of the second by hydrogen, while the third (and fourth) has remained unaltered.[3] This difference in the behavior of the three atoms of bromine is certainly very curious, and, so far as I can find, no case analogous to it has been described as yet. The strangeness of the replacement of bromine by hydrogen becomes especially evident when it is remembered that in every case there was a large excess of sodium malonic ester present, and that this second atom of bromine has therefore combined with the carbon of malonic ester (see Reaction III) in preference to the sodium of sodium malonic ester, so that the tendency to introduce hydrogen rather than the malonic ester radical has been strong enough in this case to overcome the attraction of the bromine for the sodium, and to cause it to combine with carbon instead.

I have not succeeded in finding any explanation of these curious observations which satisfies me, but hope to be led to one by further experiment. It can be stated at present, however, that the difference of behavior in the three bromine atoms is not due to differences in their position on the benzol ring. This is shown easily in the case of the tribromtrinitrobenzol, as here the three atoms of bromine occupy exactly similar positions, each being ortho to two nitro groups and para to the third. In the tribromdinitrobenzol,[1] also, the first and third atoms of bromine are similarly placed (ortho to one, para to the other nitro group), but the second (that replaced by hydrogen) is peculiar in being ortho to both nitro groups. It is evident, then, that in these reactions both similarly placed bromine atoms are not replaced by the malonic ester radical; but it is also to be observed that the bromine which is replaced by hydrogen has in every case stood in the ortho position to two nitro groups, and this suggested to me that perhaps an atom of bromine in this position might be especially susceptible to the action of free malonic ester. To test this hypothesis I mixed some tribromdinitrobenzol dissolved in benzol with malonic ester, and, after the mixture had stood for some time in the cold, warmed it for about an hour on the water-bath, but even after this treatment no action[2] had taken place, as the tribromdinitrobenzol melted unaltered at 192°. This result was confirmed by a similar experiment with acetacetic ester, which stood with tribromdinitrobenzol for six months without any action. It is evident, therefore, that this atom of bromine is not attached in an especially loose way to the molecule, and that its replacement by hydrogen does not depend only on its position with reference to the nitro groups, but is due also to the presence of the malonic ester radical.

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[1] This Journal **12**, 16 (1890).

[2] Ibid. **11**, 546 (1889).

[3] In the trinitro compound the third atom of bromine is replaced by the malonic ester radical to a limited extent even in the cold, but it is acted on much less easily than the first.

On the Relative Ease with which the Reactions take Place.

This subject will, I hope, prove susceptible of quantitative treatment, and I propose next year to try some experiments of this sort; I shall, therefore, at present confine myself to two qualitative observations, which were so marked that a quantitative confirmation of them seems unnecessary.

The tribromtrinitrobenzol is distinctly more reactive than the tribromdinitro- or tetrabromdinitrobenzol, as it acts on alcoholic ammonia in the cold, whereas the other two must be heated to 100° in sealed vessels to bring about this reaction.

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[1] In the tetrabromdinitrobenzol the fourth atom of bromine seems to have no influence on the reaction, and therefore all I say about the tribromdinitrobenzol also applies to this substance.

[2] The addition of a little aqueous sodic hydrate was enough to cause action at once, as shown by the appearance of the red color of the sodium salt.

The sodium acetacetic ester acts much less energetically than sodium malonic ester upon tribromdinitrobenzol, since the red color of the product appears instantaneously with the malonic ester, but only after some time with acetacetic ester, and the yield of the acetacetic compound is much smaller than that of the malonic derivative, if the reactions are carried on under the same conditions.

On the Acidity of the substituted Malonic Esters, Acetacetic Ester, and Ketones described in the preceding Papers.

In order to determine the relative acidity of these substances, their action with the following reagents was studied: acid sodic carbonate, sodic carbonate, ammonic hydrate, sodic hydrate. Each reagent was added in aqueous solution to the solid organic substance, and, after observing what took place, alcohol was added, and any change in the behavior of the substance noted. All these experiments were tried at the same time, great care being used to make the conditions as nearly the same as possible. The results can be divided into those which were perfectly definite, that is, where the differences consisted in the fact that one compound formed a salt with the reagent, and another did not; and those depending to a certain extent upon my judgment, in which the differences were only in the amount of salt formed, as shown by the depth of color, or in the quantity of alcohol necessary to produce the salt. The differences of the first class can be described most clearly and succinctly by the following table, in which the substances are arranged in the order of their acidity, beginning with the most acid. The columns correspond to the reagents, and the word "Salt" indicates that a salt was formed, as shown by the color imparted to the solution, or solid.

The observations recorded in this table divide these substances into the following groups (indicated by the lines):—I and II, most acid; III, IV and V, less acid; VI, less acid; VII, less acid; VIII, least acid. The relative acidity of I and II was determined by data of the second sort mentioned above, since I gave a much stronger coloration than II with aqueous sodic carbonate, ammonic hydrate, or sodic hydrate. The order of III, IV and V was determined by the following observations: With acid sodic carbonate and dilute alcohol, III and IV gave a stronger red color than V. With aqueous sodic carbonate, III

	$NaHCO_3$		Na_2CO_3		NH_4OH		$NaOH$	
	Aqueous.	With Alcohol.	Aqueous.	With Alcohol.	Aqueous.	With Alcohol.	Aqueous.	With Alcohol.
I. $C_6H_2Br(NO_2)_2C_2H_3OCHCO_2C_2H_5$	Salt	Salt	Salt	Salt	Salt	Salt	Salt	Salt
II. $C_6HBr(NO_2)_3CH(CO_2C_2H_5)_2$	Salt	Salt	Salt	Salt	Salt	Salt	Salt	Salt
III. $C_6H_2Br(NO_2)_2CH(CO_2C_2H_5)_2$	..	Salt	Salt	Salt	Salt	Salt	Salt	Salt
IV. $C_6H_2Br(NO_2)_2CH_2COCH_3$	..	Salt	[1]	Salt	Salt	Salt	Salt	Salt
V. $C_6HBr_2(NO_2)_2CH(CO_2C_2H_5)_2$	..	Salt	Salt	Salt	Salt	Salt	Salt	Salt
VI. $C_6H_2C_6H_5NH(NO_2)_2CH(CO_2C_2H_5)_2$	..	Salt	..	Salt	..	Salt	..	Salt
VII. $C_6HBrC_6H_5NH(NO_2)_2CH(CO_2C_2H_5)_2$	.	..	..	Salt	..	Salt	..	Salt
VIII. $C_6H_2C_6H_5NH(NO_2)_2CH_2COCH_3$	..	..	..	Salt	..	..	..	Salt

[1] No salt was obtained from IV with aqueous sodic carbonate, but I ascribe this to a mistaken observation, probably due to the difficulty in moistening the ketone with the aqueous solution.

gave a pale red, V a much paler, in fact barely perceptible color. With aqueous ammonic hydrate, III gave a pale red, V a very pale, barely perceptible red, and IV stood between III and V in color. With aqueous sodic hydrate, the color was confined to the crystals of the organic substance, owing to the slight solubility of the salt in a solution of sodic hydrate, and III turned dark red, IV pale red, while V showed a mixture of pale red particles of the salt and white ones of the ester. Upon adding alcohol to the mixture of the substance and either aqueous sodic carbonate or ammonic hydrate, a dark red color was obtained from all three, but much more alcohol was necessary to produce this color with V than with III or IV. My observations on the intensity of the color with different reagents confirm the order of compounds VI, VII and VIII, but I do not think it worth while to give the details. I should add, also, to show that the personal equation did not enter to any great extent into these observations, that the substances during the experiments were arranged in an order different from that of their acidity, and that the order of acidity given above derived from these experiments was a surprise to me in many particulars.

These experimental results justify the following inferences in regard to the effect of differences in composition upon the acidity of these substances:

(*a*). The introduction of an additional nitro group (in the ortho position) increases the acidity, since II is more acid than III.

(*b*). The replacement of hydrogen (in the ortho position) by bromine diminishes the acidity, since V is less acid than III.

(*c*). The replacement of bromine (in the meta position) by the aniline radical C_6H_5NH reduces the acidity very considerably, since III, IV and V are much more acid than VI, VIII and VII respectively.

In all these cases the differences occur in the benzol ring, and the effects are very marked (especially in *c*) when it is considered that the hydrogen affected is attached to the side-chain, and therefore more removed from the influence of the acid radicals than in most of the similar cases previously described, in which the element influenced was attached to the benzol ring. These observations recall some made by me several years ago, when I showed[1] that the ring bromine in the three brombenzylbromides had a marked influence in diminishing the ease with which the side-chain bromine was removed, varying with its position on the benzol ring, the para bromine having less influence than the meta, the meta than the ortho.

(*d*). The nature of the side-chain also has a marked influence on the acidity; thus the substituted acetacetic ester I is much more acid than the corresponding malonic ester III, a result in harmony with Claisen and Ehrhardt's[2] classification of the radicals according to their acid-producing power, since they give the following list, beginning with that which has the least influence, "phenyl, carboxyl, benzoyl, acetyl, formyl."

An approximate measure of the relative acid-producing power of carboxyl and acetyl is given by the comparison of III and IV, which possess nearly the same degree of acidity, and therefore it follows that one acetyl has nearly, although not quite, the same effect as two carboxyls.

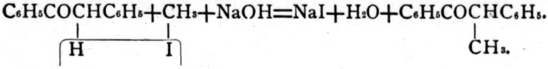
(*e*). The comparison of a dimalonic with the corresponding monomalonic compound in this respect is of interest. Unfortunately I had none of the trinitrophenylendimalonic ester when the comparison described above was made, so that this substance does not appear in the table; but by comparing the observations made on it when its properties were studied with those on the bromtrinitrophenylmalonic ester, I found that the dimalonic compound is much less acid than the brommonomalonic ester, since acid sodic carbonate in aqueous solution has no action upon it,

[1] This Journal **3**, 252 (1881).

[2] Ber. d. chem. Gesell. 1889, p. 1019.

and even aqueous sodic carbonate gives only a very faint red color.[1] This weaker acidity can be accounted for by the hypothesis that the influence of the three nitro groups being divided between two malonic ester radicals, each will have the acidifying influence of only one and a half nitro groups, instead of the three, which act on the acid hydrogen in the monomalonic compound.

The stability of the salts of all these compounds is remarkable, the sodium salt even of the anilidodinitrobenzylmethylketone (the least acid of all these substances) having been prepared and analysed with no especial difficulty; it shows, therefore, a marked difference in this respect from desoxybenzoine ($C_6H_5COCH_2C_6H_5$), the sodium compound of which, according to Victor Meyer,[2] has not been isolated. In fact, he thinks it probable that it may not exist in the free state, and leaves it doubtful whether the syntheses of homologues of desoxybenzoine are preceded by the formation of a sodium compound, as with malonic or acetacetic ester, or whether the homologue is formed direct by the removal of hydrogen and the halogen by sodic hydrate, according to this reaction:



$$C_6H_5CO\underset{H}{\underset{|}{C}}HC_6H_5+\underset{I}{\underset{|}{C}}H_3+NaOH=NaI+H_2O+C_6H_5CO\underset{CH_3.}{\underset{|}{C}}HC_6H_5.$$

The reason for this striking difference in acidity between the substituted benzylmethylketones and desoxybenzoine can hardly be due to the fact that the former contain the more active acetyl instead of the benzoyl contained in the latter, although this may have some influence, but in my opinion is rather to be ascribed to the heightening of the acid-producing power of the phenyl by the nitro groups which it contains. The salts of the acetacetic or malonic esters are much more stable than those of the ketones, as was to be expected, since in these cases the hydrogen is exposed to the acidifying power of three radicals (nitrophenyl and two carboxyls, or one carboxyl and an acetyl), and their stability almost equals that of the salts of Bischoff's[3] orthonitrobenzoylmalonic ester, in which the nitrophenyl of my compounds is replaced by the even more acid nitrobenzoyl.

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[1] I should be inclined to place the trinitrophenylendimalonic ester between III and V, although from the absence of comparative work its exact place cannot be determined with certainty; this, however, is of little importance, as the comparison of it with II is the only one of especial interest.

[2] Ber. d. chem. Gesell. 1888, p. 1291.

[3] Ann. Chem. **251**, 364.

LXX.—ON CERTAIN DERIVATIVES OF FURFURACRYLIC ACID.

BY H. B. GIBSON AND C. F. KAHNWEILER.

The preparation of furfuracrylic acid was described by v. Baeyer[1] 1877. At that time, however, the investigation of the acid was pushed in but one direction, and the successive steps by which it could be converted into α-pimelic acid were alone described in detail. It seemed that a further study of the acid in other directions also could hardly fail to yield interesting results.

The ready decomposition of furfuracrylic acid by mineral acids compelled us to relinquish the line of work we originally had proposed to follow, and we consequently began an investigation into the nature of this decomposition. The study of the action of hydrochloric acid upon an alcoholic solution of furfuracrylic acid was just beginning to yield us results when the paper of Markwald[2] upon the same subject reached us, and we were therefore obliged to abandon our work in this direction, and turned our attention to the products formed by the action of bromine, which promised to repay investigation. We felt ourselves quite at liberty to continue our study of furfuracrylic acid in this direction, since Markwald had declared himself unable to obtain well defined crystalline products in this way.

FURFURACRYLIC ACID.

In the preparation of furfuracrylic acid we have found it advantageous to modify slightly the proportions given by v. Baeyer, and in this respect our experience agrees more closely with that of Markwald. We have heated 2 parts of furfurol with 3 parts of fused sodic acetate and 3 parts of acetic anhydride with reverse cooler at 160°–170° for about ten hours, extracted the acid with a dilute solution of sodic carbonate, precipitated with hydrochloric acid, and recrystallised the product thus obtained from boiling water. Although the yield varied somewhat in successive preparations, we frequently obtained an amount equal to the weight of furfurol employed. The melting point of the pure acid we found to be 140°, in agreement with the observations of Jaffe and Cohn,[3] instead of 136° as given by v. Baeyer. From the acid we made the methyl ether and the amide, which we may describe a little more in detail, since no description of them has yet been published.

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[1] Ber. d. chem. Ges. **10**, 355.

[2] Ibid. **20**, 2811.

[3] Ibid. **20**, 2315.

Methyl Furfuracrylate, $C_7H_5O_3 . CH_3$.—By precipitating with argentic nitrate a solution of ammonic furfuracrylate, the silver salt was obtained as a heavy curdy precipitate. This was carefully dried and treated with an excess of methyl iodide. When the decomposition was complete the product of the reaction was extracted with ether, and purified by distillation under diminished pressure. Under a pressure of 15 mm. the methyl furfuracrylate distills unchanged at 112°, and the distillate solidifies in beautiful rhombic crystals which melt at 27°. Under a pressure of 774 mm. we found that the ether distilled without apparent decomposition at 227°–228°. It possessed an agreeable characteristic odor, and dissolved readily in alcohol, ether, ligroin, or benzol. An analysis give the following results:

0.2224 gram substance gave 0.5157 gram CO_2 and 0.1084 gram H_2O.

	Calculated for $C_8H_8O_3$.	Found.
C	63.17	63.23
H	5.26	5.42

Furfuracrylamide, $C_7H_5O_2.NH_2$.—Concentrated aqueous ammonic hydrate acted but slowly upon methyl furfuracrylate in the cold, but at 100° in sealed tube the decomposition was readily effected. The amide was sparingly soluble in cold water, more readily in hot water, and crystallised in pearly scales which melted at 168°–169°.

I. 0.4076 gram substance gave 35.5 cc. moist nitrogen at 21.4° and under a pressure of 766 mm.

II. 0.4590 gram substance gave 41.9 cc. moist nitrogen at 21.7° and under a pressure of 767 mm.

	Calculated for $C_7H_7NO_2$.	Found. I.	II.
N	10.22	9.98	10.45

Action of Bromine.

It had already been observed by v. Baeyer that furfuracrylic acid was readily attacked by aqueous bromine, but he had made no careful study of the products formed. Since the product formed in this way was uninviting, and the reaction undoubtedly complicated, it seemed advisable to study instead the action of dry bromine, which might yield well characterised addition products. We soon found, however, that with dry bromine even in the cold substitution was readily effected, so that the simplest well defined product contained three atoms of bromine. Subsequent study showed that this product was a saturated compound in which one atom of bromine had take its place in the furfuran ring.

Bromfurfurdibrompropionic Acid, $C_7H_5Br_3O_3$.—If furfuracrylic acid is suspended in ten times its weight of carbonic disulphide and two molecules of dry bromine added, a clear deep red solution is at once obtained, from which hydrobromic acid is soon evolved in quantity. Although the reaction progresses steadily at ordinary temperatures, it may be greatly hastened by heat, and we usually have heated the mixture upon the water-bath soon after the addition of the bromine. When the evolution of the hydrobromic acid slackens, and a crystalline substance has separated in quantity, the solution is well cooled, filtered, and the crystalline solid well washed with cold carbonic disulphide. The substance then gives on analysis percentages which closely agree with those required by the formula $C_7H_5Br_3O_3$; but it may still further be recrystallised from hot benzol or carbonic disulphide.

I. 0.2080 gram substance gave 0.3117 gram AgBr.

II. 0.3798 gram of substance recrystallised from carbonic disulphide gave 0.3099 gram CO_2 and 0.0502 gram H_2O.

III. 0.2005 gram substance recrystallised from benzol gave 0.2998 gram AgBr.

IV. 0.2003 gram substance recrystallised from benzol gave 0.2993 gram AgBr.

	Calculated for $C_7H_5Br_3O_3$.	Found.			
		I.	II.	III.	IV.
C	22.28	...	22.26	...	...
H	1.33	...	1.47	...	...
Br	63.66	63.78	...	63.65	63.60

Bromfurfurdibrompropionic acid crystallises in small flat oblique prisms, which are sparingly soluble in cold benzol or carbonic disulphide, more readily in hot. It is readily soluble in alcohol or ether, insoluble in water, although slowly decomposed by it. On heating, the acid is gradually decomposed, with the evolution of hydrobromic acid and slight carbonisation. As might be expected, we found it impossible to prepare salts, or even ethers, of the acid.

The action of cold water upon the acid was so well marked that we proceeded to determine the products formed. When bromfurfurdibrompropionic acid is suspended in water, carbonic dioxide soon begins to escape, and after long standing the crystalline solid is completely converted into a colorless oil. The aqueous solution then contains hydrobromic acid in abundance. As the decomposition was greatly facilitated by gentle heat, we usually have allowed the reaction to proceed at about 40°. When the decomposition was complete, we distilled with steam, and dried the heavy colorless oil thus obtained with calcic chloride. On distillation under diminished pressure, we found that this oil began to boil at 108° under a pressure of 14 mm., and that the thermometer gradually rose to 112°, the pressure remaining constant. The distillate was at first nearly colorless, and of high refractive power, but on standing it quite rapidly became dark-colored. Analyses of the freshly distilled substance showed it to be a bromfurfurbromethylen.

I. 0.3173 gram substance gave 0.3350 gram CO_2 and 0.0476 gram H_2O.

II. 0.1928 gram substance gave 0.2883 gram AgBr.

III. 0.2045 gram substance gave 0.3056 gram AgBr.

	Calculated for $C_6H_4Br_2O$.	Found. I.	II.	III.
C	28.57	28.79	...	...
H	1.59	1.67	...	...
Br	63.49	...	63.65	63.60

The reaction is then strictly analogous to what by which β-bromstyrol may be made from phenyldibrompropionic acid:

$$C_7H_5Br_3O_3 = C_6H_4Br_2O + CO_2 + HBr.$$

The aqueous solution left in the retort after distillation with steam deposited on long standing a small quantity of a crystalline acid. The quantity of this acid was so insignificant that we were able to identify it only after uniting the products obtained in many successive preparations. Two determinations of the percentage of bromine showed the acid to be the bromfurfuracrylic acid subsequently described. Lack of material made it impossible to prove with precision the identity of the two acids, and we can therefore only assert their close resemblance.

I. 0.1262 gram substance gave 0.1091 gram AgBr.

II. 0.1956 gram substance gave 0.1700 gram AgBr.

	Calculated for $C_7H_5BrO_3$.	Found. I.	II.
Br	36.86	36.79	36.99

We have hitherto been unable to find other definite products of the reaction.

By the action of bromine upon bromfurfurbromethylen we could obtain no products which invited further study. On the other hand, alcoholic potassic hydrate gave us the corresponding acetylen derivative, although we have not yet isolated it in a pure condition. The oil obtained as the direct product of the reaction contained much too large a percentage of bromine, and prolonged action at a higher temperature gave no more satisfactory results. That the oil contained the acetylen derivative was readily shown by its behavior with an ammoniacal solution of silver or copper. The silver compound was white, the copper compound a greenish yellow. The latter was made in larger quantity, carefully washed by decantation, and dried over sulphuric acid. It then exploded violently by heat or on contact with fuming nitric acid, and contained the required percentage of copper.

I. 0.6479 gram substance gave by electrolysis 0.1748 gram Cu.

II. 0.6178 gram substance gave 0.1681 gram Cu.

	Calculated for $(C_6H_2BrO)_2Cu_2$.	Found. I.	II.
Cu	27.16	26.98	27.20

From the copper compound we attempted to prepare the bromfurfuracetylen in a pure condition. By decomposing with acid, extracting with ether, and distilling the well dried extract under diminished pressure, we obtained a colorless oil which boiled at 65°-68° under a pressure of 19 mm. This oil contained a percentage of bromine, which left no doubt as to its identity, but showed at the same time that it was still impure. We have as yet made no further attempt at its complete purification.

It seemed to us of interest to prepare by oxidation the diacetylene derivative also, analogous to the diacetenylphenyl of Glaser,[1] which was afterward more fully studied by v. Baeyer and Landsberg.[2] In its preparation we followed closely the method of v. Baeyer. To the copper compound was added one molecule of potassic ferricyanide in aqueous solution. When the oxidation was complete, the precipitate formed was collected on a filter, dried, and extracted with hot alcohol. On cooling the alcohol deposited

[1] Ann. Chem. (Liebig) **154**, 159.

[2] Ber. d. chem. Ges. **15**, 57.

the new compound in small iridescent plates which melted at 126°. It was readily soluble in hot alcohol, sparingly in cold alcohol, and dissolved freely in ether, chloroform, benzol, or ligroin. Analysis showed the substance to be dibromdifurfurdiacetylene (diacetylene-bromfurfuryl):

$$C_4H_2BrO - C \equiv C - C \equiv C - C_4H_2BrO.$$

I. 0.2476 gram substance gave 0.3888 gram CO_2 and 0.0383 gram H_2O.

II. 0.1538 gram substance gave 0.1696 gram AgBr.

III. 0.1548 gram substance gave 0.1702 gram AgBr.

	Calculated for $C_{12}H_4Br_2O_2$.	Found I.	II.	III.
C	42.36	42.82	...	...
H	1.18	1.72	...	...
Br	47.06	...	46.93	46.79

BROMFURFURACRYLIC ACID.

The behavior of the acid containing three atoms of bromine which was obtained by the direct action of bromine upon furfuracrylic acid left little doubt that it was a bromfurfurdibrompropionic acid. If this view were correct, it seemed not improbable that the bromine attached to the side-chain might be removed without disturbing the bromine in the furfuran ring, and that a bromfurfuracrylic acid would thus be formed. After a few preliminary experiments it was found that zinc dust added to an alcoholic solution of the bromfurfurdibrompropionic acid brought about the desired result. The reaction is vigorous, and the boiling point of the alcohol soon reached. When the reaction is over, water is added to the filtered solution, and the acid which is thus precipitated is purified by conversion into its sodium salt, reprecipitation with hydrochloric acid, and recrystallisation from dilute alcohol or boiling water. The yield of the new acid thus obtained was between 80 and 90 per cent. of the theoretical amount, and analysis showed that it had the desired composition.

I. 0.2645 gram substance gave 0.3768 gram CO_2 and 0.0566 gram H_2O.

II. 0.2511 gram substance gave 0.2161 gram AgBr.

III. 0.2223 gram substance gave 0.1920 gram AgBr.

IV. 0.1490 gram substance gave 0.1288 gram AgBr.

	Calculated for $C_7H_5BrO_3$.	Found. I.	II.	III.	IV.
C	38.71	38.86	...	...	...
H	2.30	2.38	...	...	...
Br	36.86	...	36.63	36.76	36.80

Bromfurfuracrylic acid crystallises in long slender prisms, which are sparingly soluble in cold water, more readily in hot water. The acid dissolves readily in alcohol, ether, hot benzol, or hot chloroform, in cold benzol or cold chloroform it is but sparingly soluble, and it is nearly insoluble in ligroin. It melts sharply at 176°–177°, but since it is somewhat decomposed and blackened by long continued heating above 150°, the bath must first be heated to within a few degrees of the melting point. Small quantities of the acid may readily be sublimed between watch-glasses. The sublimed product also melts at 176°–177°, and darkens upon long heating. With bromine the acid unites readily, and forms the original substituted propionic acid. We have made many attempts to convert the acid into the corresponding substituted pyromucic acid, or to obtain from it by oxidation a product which should enable us to fix the position of the bromine atom, but hitherto without success. We can, therefore, at present only conjecture that the bromine in this case, as with the pyromucic acid, enters first the δ position. For the further characterisation of the acid we have prepared a few of its salts.

Baric Bromfurfuracrylate, $Ba(C_7H_4BrO_3)_2.H_2O$.—The barium salt is sparingly soluble in cold water, somewhat more readily in hot water, and crystallises in clustered needles. When air-dried it loses nothing over sulphuric acid, gives up one molecule of water slowly at 100°, and is decomposed at a somewhat higher temperature.

I. 1.1830 gram of the air-dried salt lost at 100° 0.0380 gram H_2O.

II. 0.7064 gram of the air-dried salt lost at 100° 0.0227 gram H_2O.

III. 0.4898 gram of the air-dried salt gave 0.1951 gram $BaSO_4$.

	Calculated for $Ba(C_7H_4BrO_3)_2.H_2O$.	Found. I.	II.	III.
H_2O	3.07	3.21	3.21	...
Ba	23.34	...	...	23.42

I. 0.5258 gram of the salt dried at 100° gave 0.2149 gram $BaSO_4$.

II. 0.4787 gram of the salt dried at 100° gave 0.1955 gram $BaSO_4$.

	Calculated for $Ba(C_7H_4BrO_3)_2$.	Found.	
		I.	II.
Ba	24.07	24.02	24.01

Calcic Bromfurfuracrylate, $Ca(C_7H_4BrO_3)_2.3H_2O$.—This salt crystallises in columnar aggregations of plates, and is sparingly soluble in cold water, more readily in hot water. The air-dried salt effloresces over sulphuric acid, and is gradually decomposed at 100°, but may be dried without difficulty at 80°–85°.

I. 1.1639 gram of the air-dried salt lost at 82° 0.1184 gram H_2O.

II. 0.7362 gram of the air-dried salt lost at 83°–85° 0.0740 gram H_2O.

III. 0.6331 gram of the air-dried salt gave 0.1648 gram $CaSO_4$.

IV. 0.5287 gram of the air-dried salt gave 0.1375 gram $CaSO_4$.

	Calculated for $Ca(C_7H_4BrO_3)_2.3H_2O$.	Found.			
		I.	II.	III.	IV.
H_2O	10.07	10.17	10.05	...	...
Ca	7.61	...	...	7.65	7.65

0.6123 gram of the salt dried at 82° gave 0.1774 gram $CaSO_4$.

	Calculated for $Ca(C_7H_4BrO_3)_2$.	Found.
Ca	8.47	8.52

Sodic Bromfurfuracrylate, $NaC_7H_4BrO_3$.—This salt is readily soluble even in cold water, and crystallises in anhydrous nodular aggregations.

I. 0.7612 gram of the salt gave 0.2228 gram Na_2SO_4.

II. 0.7589 gram of the salt gave 0.2206 Na_2SO_4.

	Calculated for $NaC_7H_4BrO_3$.	Found.	
		I.	II.
Na	9.62	9.48	9.42

Argentic Bromfurfuracrylate, $AgC_7H_4BrO_3$.—The silver salt, formed by the addition of argentic nitrate to a neutral solution of the ammonium salt, proved to be nearly insoluble in water, and was apparently amorphous.

I. 0.3919 gram salt gave 0.2261 gram AgBr.

II. 0.4065 gram of the salt gave 0.2347 gram AgBr.

	Calculated for $AgC_7H_4BrO_3$.	Found.	
		I.	II.
Ag	33.34	33.13	33.16

Ethyl Bromfurfuracrylate, $C_7H_4BrO_3.C_2H_5$.—To a solution of the acid (5 parts) in somewhat more than its own weight of absolute alcohol (6.5 parts) was added concentrated sulphuric acid (3 parts), and the mixture heated upon the water-bath for two or three hours. We found that too long heating should be avoided, since decomposition then ensued, and a product was formed which undoubtedly was analogous to that obtained by Markwald.[1] We have, however, made no careful study of it. As soon as the etherification appeared to be complete, the ether was precipitated with water, dried with calcic chloride, and distilled under diminished pressure. The greater part of the product distilled at 151°–152° under a pressure of 14 mm., and on cooling this distillate completely solidified. From ligroin the ether could be obtained in large flat prisms, which melted at 42°. It was readily soluble in alcohol, ether, chloroform, benzol, or ligroin, and had a faint aromatic odor.

I. 0.1968 gram substance gave 0.3168 gram CO_2 and 0.0673 gram H_2O.

II. 0.2251 gram substance gave 0.1722 gram AgBr.

III. 0.2545 gram substance gave 0.1943 gram AgBr.

	Calculated for $C_9H_9BrO_3$.	Found. I.	II.	III.
C	44.08	43.88	...	...
H	3.67	3.80	...	..
Br	32.65	...	32.55	32.49

We further attempted to make the amide, but found that the ether was hardly attacked by concentrated ammonic hydrate at 100°, and that at a much higher temperature (215°) most of the ether employed also remained unchanged.

BROMFURFURBROMACRYLIC ACID.

It already has been mentioned that bromfurfurdibrompropionic acid is decomposed by heat with the evolution of hydrobromic acid, and the simultaneous formation of a disubstituted furfuracrylic acid might be inferred. We have made many attempts to bring about this loss of one molecule of hydrobromic acid by more convenient and more economical methods, but without success. In alcoholic solution potassic hydrate gave chiefly the ethylen derivative and potassic carbonate, no matter how the conditions of the reaction were varied. A number of high boiling neutral solvents gave no better results than those obtained by heating the acid by itself. The bromfurfurdibrompropionic acid was therefore carefully heated in shallow crystallising dishes immersed in a sulphuric acid bath. The hydrobromic acid thus escaped without blackening the product to any great extent. The temperature was slowly raised to 130°, and when at this point the formation of hydrobromic acid was no longer noticeable, the residue was boiled with dilute ammonic hydrate filtered, heated with boneblack, and the filtered solution concentrated by evaporation. In this way sparingly soluble finely felted needles of ammonic bromfurfurbromacrylate were obtained, which yielded the acid in a state of purity.

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[1] Loc. cit.

I. 0.2246 gram substance gave 0.2328 gram CO_2 and 0.0317 gram H_2O.

II. 0.2290 gram substance gave 0.2373 gram CO_2 and 0.0314 gram H_2O.

III. 0.2059 gram substance gave 0.2615 gram AgBr.

IV. 0.2025 gram substance gave 0.2571 gram AgBr.

	Calculated for $C_7H_4Br_2O_3$.	Found.			
		I.	II.	III.	IV.
C	28.38	28.27	28.26	...	...
H	1.35	1.57	1.53	...	...
Br	54.05	...	...	54.04	54.03

Bromfurfurbromacrylic acid is almost insoluble even in hot water. It dissolves freely in ether or alcohol, and when precipitated by water from a hot alcoholic solution is obtained in fine clustered needles. At ordinary temperatures it is very sparingly soluble in chloroform or carbonic disulphide, but dissolves somewhat more freely on heating. The acid melts at 178°–179°, and small quantities of it may easily be sublimed without essential decomposition.

In spite of many attempts, we have been unable to obtain experimental evidence as to the position of the bromine atoms. We have also been unable to prepare definite products by the addition of bromine to the acid, or to form from it bromfurfurpropiolic by the elimination of hydrobromic acid. The following salts may serve for the better characterisation of the acid.

Baric Bromfurfurbromacrylate, $Ba(C_7H_3Br_2O_3)_2.2H_2O$.—This salt was prepared by adding baric chloride to a solution of the ammonium salt. It is very sparingly soluble even in boiling water, and crystallises in lustrous scales. The air-dried salt contains two molecules of water, which it does not lose over sulphuric acid.

I. 1.4911 gram of the air-dried salt lost at 120° 0.0674 gram H_2O.

II. 0.8824 gram of the air-dried salt lost at 120° 0.0399 gram H_2O.

	Calculated for $Ba(C_7H_3Br_2O_3)_2.2H_2O$.	Found. I.	II.
H_2O	4.72	4.52	4.52

I. 0.2130 gram of the anhydrous salt gave 0.0684 gram $BaSO_4$.

II. 0.2229 gram of the anhydrous salt gave 0.0712 gram $BaSO_4$.

III. 0.4376 gram of the anhydrous salt gave 0.1398 gram $BaSO_4$.

	Calculated for $Ba(C_7H_3Br_2O_3)_2$.	Found. I.	II.	III.
Ba	18.85	18.88	18.78	18.78

Argentic Bromfurfurbromacrylate, $AgC_7H_3Br_2O_3$.—The silver salt made by precipitation is very sparingly soluble even in boiling water, and is apparently amorphous.

I. 0.2052 gram of the salt dried over sulphuric acid gave 0.0951 gram AgBr.

II. 0.2101 gram of the salt dried over sulphuric acid gave 0.0977 gram AgBr.

	Calculated for $AgC_7H_3Br_2O_3$.	Found. I.	II.
Ag	26.80	26.62	26.71

Potassic Bromfurfurbromacrylate, $KC_7H_3Br_2O_3$.—The potassium salt is sparingly soluble in cold water, more readily soluble in hot water, and crystallises in slender clustered needles which are anhydrous.

I. 0.2275 gram of the salt gave 0.0589 gram K_2SO_4.

II. 0.5386 gram of the salt gave 0.1407 gram K_2SO_4.

	Calculated for $KC_7H_3Br_2O_3$.	Found. I.	II.
K	11.70	11.62	11.72

Ethyl Bromfurfurbromacrylate, $C_7H_3Br_2O_3.C_2H_5$.—The ethyl ether was made by heating for three hours on the water-bath a solution of the acid (4 parts) in absolute alcohol (40 parts), with the addition of a small amount (3 parts) of concentrated sulphuric acid. The ether was then precipitated with water, washed with a dilute solution of sodic carbonate, and recrystallised from ligroin. It crystallised easily in radiated needles which melted at 55°–56° and dissolved readily in alcohol, ether, chloroform, benzol, ligroin, or carbonic disulphide.

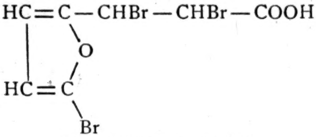
I. 0.3774 gram of substance gave 0.4592 gram CO_2 and 0.0849 gram H_2O.

II. 0.2125 gram substance gave 0.2464 gram AgBr.

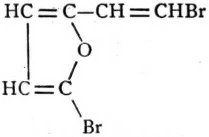
III. 0.2179 gram substance gave 0.2525 gram AgBr.

	Calculated for $C_9H_8Br_2O_3$.	Found. I.	II.	III.
C	33.34	33.19	...	...
H	2.47	2.50	...	...
Br	49.39	...	49.35	49.32

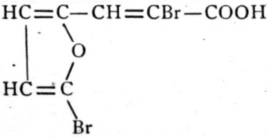
While we have been unable to establish with precision the constitution of the foregoing derivatives of furfuracrylic acid, the analogies offered by the derivatives of pyromucic and cinnamic acids naturally suggest the following formulae for the substances in question:



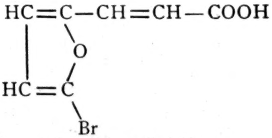
Bromfurfurdibrompropionic Acid.



Bromfurfurbromethylen.



Bromfurfurbromacrylic Acid.



Bromfurfuracrylic Acid.

LXXI.—ON THE SO-CALLED DIOXYMALEIC ACID.

By W. S. Hendrixson.

Several years ago Bourgoin[1] announced the discovery of two new acids which he had obtained by replacing the bromine of brommaleic and dibrommaleic acid by hydroxyl, and which he therefore called oxymaleic and dioxymaleic acid. Although the experimental evidence as to the existence of these acids was very slight, and their assumed structure wholly anomalous, they soon found place in many text-books.

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[1] Bull. Soc. Chim. **19**, 482; **22**, 443.

In 1886, at the suggestion of Fittig, the work of Bourgoin upon oxymaleic acid was repeated by Scherks,[1] who found that his statements were without foundation, and that brommaleic acid in aqueous solution was not in the least attacked by argentic oxide, even at 100°. Scherks further concluded that Bourgoin's statements concerning his dioxymaleic acid must also be incorrect, because the dibrommaleic acid which he used he claimed to have made from his tribromsuccinic acid, an acid which could not be formed under the given conditions, as shown by Fittig and Petri,[2] or if formed, would at once be decomposed into dibromacrylic acid and carbonic dioxide. This conclusion of Scherks seems hardly justified by Bourgoin's statements. The dibrommaleic acid which he used undoubtedly was made by the action of aqueous bromine upon succinic acid, and, while his material may have been far from pure, the question of its identity is in no way affected by his erroneous assumption that it had been formed by the decomposition of tribromsuccinic acid. In any case the subject seemed to demand a more careful investigation. At the suggestion of Prof. H. B. Hill, I have, therefore, repeated Bourgoin's work upon dioxymaleic acid, and find that decomposition is in this case readily effected, but that the product formed is not dioxymaleic acid.

The dibrommaleic acid needed for this investigation was made by the oxidation of mucobromic acid with cold fuming nitric acid, a method which had already been found in this laboratory to be much more advantageous than the methods previously described. Mucobromic acid was dissolved in cold fuming nitric acid, and the nearly saturated solution allowed to stand for several days at ordinary temperatures. When the mixture had completely solidified, the nitric acid was expelled by gentle heat, and the dry residue distilled from a small retort. In order to obtain a perfectly pure product, the distillate was dissolved in water, neutralised with baric carbonate, and the baric dibrommaleate precipitated by the addition of alcohol. The barium salt was then converted into the sodium salt, and from this the silver salt was made by precipitation with argentic nitrate.

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[1] Ann. Chem. (Liebig) **207**, 223.

[2] Ibid. **195**, 70.

According to Bourgoin, dioxymaleic acid is formed by heating argentic dibrommaleate with water to 150°. On opening the tubes after heating for five hours he found that carbonic dioxide escaped, that argentic bromide had been formed, and that the liquid in the tubes was distinctly acid. On the addition of argentic nitrate to this acid solution carefully neutralised with ammonic hydrate he obtained a white insoluble silver salt, which gave on ignition a residue closely agreeing with the weight of metallic silver required by the formula $Ag_2C_4H_2O_6$. He found the acid to be a white crystalline solid, which was readily soluble in water and alcohol, and barely soluble in ether. With the alkalies and alkaline earths it formed readily soluble salts, and showed itself to be non-saturated in that it was capable of fixing hydrogen and bromine. Bourgoin gives, however, no analytical results whatsoever except the one already mentioned.

On following closely the directions of Bourgoin, I found that the argentic dibrommaleate had been almost completely decomposed, and that at least 95 per cent. of the theoretical amount of argentic bromide had been formed. The liquid in the tubes was strongly acid, but the carbonic dioxide which escaped was by no means insignificant in quantity. Although the aqueous solution gave a crystalline precipitate with argentic nitrate after careful neutralisation with ammonic hydrate, it was thought advisable to distill the liquid with steam before preparing salts for analysis, since it was found that the acid volatilised readily under these conditions. The acid distillate was neutralised with calcic carbonate, the silver salt precipitated by the addition of argentic nitrate to the concentrated solution, and recrystallised from hot water. The silver salt thus obtained closely resembled argentic acetate, and its identity was established by analysis.

I. 0.4677 gram of the air-dried salt gave 0.5249 gram AgBr.

II. 0.2263 gram of the air-dried salt gave 0.1465 gram Ag.

III. 0.2056 gram of the salt dried over sulphuric acid gave 0.1082 gram CO_2, 0.0330 gram H_2O, and 0.1327 gram Ag.

	Calculated for $AgC_2H_3O_2$.	Found. I.	II.	III.
Ag	64.67	64.46	64.73	64.54
C	14.37	...	...	14.35
H	1.80	...	...	1.78

The barium salt was also made by neutralising the acid distillate with baric carbonate. The salt obtained on evaporation was either recrystallised from water, or precipitated from a concentrated aqueous solution by alcohol. I failed to find any definite statements as to the composition of the salt thus precipitated by alcohol, but experiments of my own showed that it contained one molecule of water like the salt crystallised from water.

I. 1.1456 gram of the air-dried salt lost at 150° 0.0780 gram H_2O.

II. 0.9187 gram of the air-dried salt lost at 125° 0.0609 gram H_2O.

III. 0.4561 gram of the air-dried salt gave 0.3899 gram $BaSO_4$.

IV. 0.6868 gram of the air-dried salt gave 0.5841 gram $BaSO_4$.

	Calculated for $Ba(C_2H_3O_2)_2.H_2O$.	Found. I.	II.	III.	IV.
H_2O	6.59	6.80	6.62	...	...
Ba	50.18	...	..	50.25	50.02

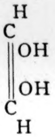
0.8554 gram of the salt dried at 125° gave 0.7811 gram $BaSO_4$.

	Calculated for $Ba(C_2H_3O_2)_2$.	Found.
Ba	53.73	53.69.

It thus appears that acetic acid is formed in the decomposition of argentic dibrommaleate by water at 150° and the reaction may be expressed by the equation:

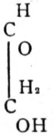
$$Ag_2C_4Br_2O_4 + 2H_2O = 2AgBr + CO_2 + C_2H_4O_2.$$

The weight of baric acetate which was obtained from the distilled liquid amounted to about 60 per cent. of the theoretical yield required by this equation, while 85 per cent. of the theoretical amount of free acid, calculated as acetic acid, was found by direct titration of the contents of the tubes. The higher result in the latter case may in part have been due to incomplete expulsion of the carbonic dioxide, but the most careful search failed to show that any well defined organic acid except acetic acid had been formed in the reaction. Dibrommaleic acid therefore yields, under the conditions prescribed by Bourgoin for its conversion into dioxymaleic acid, carbonic dioxide and acetic acid. The facts observed give no certain information as to the mechanism of the reaction. If it is assumed that the body



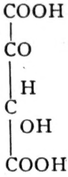
$$\begin{array}{l} \mathrm{H} \\ \mathrm{C} \\ \| \mathrm{OH} \\ \| \mathrm{OH} \\ \mathrm{C} \\ \mathrm{H} \end{array}$$

is first formed, it would pass at once into the aldehyde alcohol,



$$\begin{array}{l} \mathrm{H} \\ \mathrm{C} \\ | \mathrm{O} \\ | \mathrm{H_2} \\ \mathrm{C} \\ \mathrm{OH} \end{array}$$

from which acetic acid would then be formed, precisely in the same way that tartronic acid is formed from dibrompyruric acid,[1] or from dioxytartaric acid.[2] It is more probable, however, that the ketone acid



$$\begin{array}{l} \mathrm{COOH} \\ | \\ \mathrm{CO} \\ | \mathrm{H} \\ \mathrm{C} \\ | \mathrm{OH} \\ \mathrm{COOH} \end{array}$$

is the first product, and that this passes into acetic acid in a similar way through the loss of carbonic dioxide.

THE ELECTROLYSIS OF METALLIC PHOSPHATES IN ACID SOLUTION.

By Edgar F. Smith.

Some experiments on the action of the current upon metallic phosphates have been published by Moore,[3] and more recently Brand[4] has communicated his experience with the pyrophosphates dissolved in an excess of sodium pyrophosphate and also in ammonium hydroxide or carbonate. The experiments in this paper relate wholly to the deposition of metals from the solutions of their phosphates in normal phosphoric acid. The course pursued in the preparation of the solutions for electrolysis was to first precipitate the metals with an excess of disodium phosphate, dissolving the compound obtained in a measured volume of free phosphoric acid (sp. gr. 1.347), and then exposing this liquid to the action of currents of known strength. When operating upon mercuric solutions, prepared in the manner indicated, the deposition of the metal in the early part of the experiment was perfectly satisfactory, but as the decomposition advanced, a heavy white precipitate appeared in the solution, and, although it gradually suffered reduction, the metal that separated was so fluid-like that it mechanically carried down impurities, hence was unfit for electrolytic determinations, and the experiments in this direction were consequently suspended. Mercurous phosphate proved to be insoluble, or nearly so, in phosphoric acid. This is also the case with bismuth and lead phosphates, therefore neither of these metals was available in the proposed experiments.

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[1] Grimaux, Bull. Soc. Chim. **27**, 440.

[2] Kékulè, Ann. Chem. (Liebig) **221**, 230.

[3] Chem. News **53**, 209.

[4] Zeit. für anal. Chem. **28**, 581.

Copper.

To a solution containing 0.0996 gram metallic copper, as sulphate, 10 cc. Na_2HPO_4 (sp. gr. 1.0358) and 3½ cc. H_3PO_4 (sp. gr. 1.347) were added. The precipitated copper phosphate dissolved in ½ cc. of acid, so that the deposition of metal occurred in the presence of 3 cc. of free phosphoric acid. The total dilution with water amounted to 125 cc. The current employed gave 0.15 cc. oxyhydrogen gas per minute. The copper deposit weighed 0.0997 gram. The metal precipitation was allowed to continue through the night. Later, two additional experiments were arranged in every respect similar to the one just described, increasing the current, however, to 0.5 cc. oxyhydrogen gas per minute. The copper found was in (*a*) 0.0990 gram, and in (*b*) 0.0994 gram. The addition of an excess of ammonium hydroxide to the filtrates did not produce the slightest blue coloration. The metallic copper from the above experiments showed a rich red color. The metallic lustre observed upon the metal deposited from solutions containing other free acids, *e. g.* HNO_3, was not noticed here. That the conditions of the preceding depositions will answer for the separation of copper from other metals is evident from the results recorded below. Strong currents deposit metallic iron and other metals from their phosphates in phosphoric acid solution, while they are unaffected by the feebler currents.

Copper from Iron.

A solution containing 0.0996 gram metallic copper, 0.1700 gram metallic iron, 30 cc. Na_2HPO_4 (sp. gr. 1.0358), and 4½ cc. H_3PO_4 (sp. gr. 1.347), were diluted to 125 cc. with water and exposed to the action of a current generating 0.6 cc. oxyhydrogen gas per minute. The deposited copper weighed 0.0996 gram. Additional experiments verified this result. The filtrates contained no copper.

Copper from Aluminium.

Here the quantity of copper was the same as before, while the aluminium metal was 0.1000 gram, 20 cc. Na_2HPO_4 (sp. gr. 1.0358) with 3 cc. H_3PO_4 (sp. gr. 1.347). The total dilution was 100 cc. The current gave 0.3 cc. oxyhydrogen gas per minute. The copper deposited weighed 0.0995 gram.

Copper from Chromium.

Both metals were added as sulphates, the quantity of metallic chromium being in excess of that of the copper. The volume of alkaline phosphate was 20 cc., and that of the phosphoric acid 3 cc. The final dilution and current strength were the same as in the separation of copper from aluminium. The deposition was made during the night. The metal obtained equaled 0.0994 gram. It was brilliant red in color, similar to that noticed frequently by chemists in the separation of these two metals from each other. The chromium was oxidised to chromic acid. The filtrate gave no indication of unprecipitated copper. A duplicate experiment afforded a similar result.

Copper from Zinc.

In this separation there were present 0.1500 gram metallic zinc and alkaline phosphate and free phosphoric acid in the same quantities as with aluminium and chromium. The dilution was 100 cc. while the current gave but 0.15 cc. oxyhydrogen gas per minute. The deposited copper weighed 0.0993 gram. The filtrate gave no coloration upon the addition of an excess of ammonium hydroxide.

Copper from Cobalt.

With 0.0968 gram cobalt and conditions similar to those just given under copper and zinc, except that the current had increased to 0.22 cc. oxyhydrogen gas per minute, the deposited metal was found to be 0.0995 gram.

Copper from Nickel.

The nickel (0.1105 gram) was present as chloride, while the conditions of experiment were similar to those in the preceding example. The deposit of copper weighed 0.0996 gram.

In all of the experiments given above the copper deposited rapidly from the cold solutions. Before interrupting the current the acid liquid was siphoned off and replaced by water. The deposits were washed with cold and hot water. Alcohol and ether were not used. The drying was done upon a warm iron plate. The current employed was obtained from ten ordinary "crowfoot" cells. In each experiment the poles of the battery were about ¾ inch apart.

Cadmium.

As this metal deposits from solutions containing free sulphuric acid,[1] it was expected that the same would occur in the presence of free phosphoric acid. This is proved by the following experiments: 10 cc. cadmium sulphate ($=0.1827$ gram Cd) were precipitated by an excess of Na_2HPO_4 (sp. gr. 1.0358) and the phosphate dissolved in 1½ cc. H_3PO_4 (sp. gr. $=1.347$). Total dilution 100 cc. The current gave 0.6 cc. oxyhydrogen gas per minute. Two determinations were made in this way. The found metal was in (*a*) 0.1839 gram and in (*b*) 0.1820 gram. The (*a*) deposit showed a little sponginess, and this doubtless caused it to give a higher result than required by the theory. The filtrates from these deposits gave no cadmium reactions upon applying the usual tests for that metal. In two other determinations where the only change made in the conditions of experiment was the reduction of the current to 0.40 cc. gas per minute, the deposited cadmium weighed in (*a*) 0.1828 gram and in (*b*) 0.1833 gram. These figures indicate complete deposition and that the method is reliable. Cadmium does not, however, deposit as rapidly as copper under like circumstances. It was also found advisable towards the close of the experiment to increase the current strength. The acid liquid should always be removed from the dish in which the deposition occurs before the current is finally interrupted. The deposits were washed and dried as described with copper.

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[1] This Journal **2**, 41.

Cadmium from Zinc.

0.1827 gram cadmium and 0.1500 gram zinc (both as sulphates) were precipitated by 40 cc. disodium phosphate, dissolved in 3 cc. H_3PO_4 (sp. gr. 1.347), and acted upon in the cold for twelve hours with a current giving 0.35 cc. oxyhydrogen gas per minute. The cadmium deposit weighed 0.1820 gram. The entire dilution was 125 cc. With a second cadmium solution (= 0.1057 gram Cd), together with the same quantity of zinc as before, 20 cc. Na_2HPO_4 (sp. gr. 1.0358), 3 cc. H_3PO_4 (sp. gr. = 1.347), and 100 cc. water, 0.1060 gram cadmium was obtained. This deposit was crystalline, but in spots slightly spongy, which may account for its being somewhat higher than the theoretical. Two more separations of these metals were made, with a reduction of the phosphoric acid from 3 cc. to 2 cc., otherwise the conditions remained as before, and the cadmium obtained was in (*a*) 0.1057 gram and in (*b*) 0.1051 gram. The current strength in these depositions was 0.37 cc. oxyhydrogen gas per minute in each dish. *b* is low; its filtrate gave a trace of cadmium sulphide upon testing with hydrogen sulphide. My experience has been that in experiments such as these it should never be omitted to increase the current for about one hour previous to the final disconnection.

Cadmium from Nickel.

Only two experiments were made with these metals. They were conducted in the same manner as those with zinc and cadmium. The cadmium found was in (*a*) 0.1059 gram and in (*b*) 0.1051.

Cadmium from Iron.

The quantities of the metals were 0.1700 gram iron and 0.1057 gram cadmium. The alkaline phosphate and phosphoric acid were the same as with cadmium and zinc. Total dilution 100 cc. Current 0.37 cc. oxyhydrogen gas per minute. The deposited cadmium weighed in (*a*) 0.1058 gram and in (*b*) 0.1062 gram.

Cadmium from Chromium.

In this separation the conditions were the same as with the preceding metals. Found cadmium was 0.1055 gram. The deposit was spongy, and the reduction of the strength of the current seemed not to remove this undesirable feature.

Cadmium from Aluminium.

The quantity of cadmium present was 0.2120 gram, while the aluminium was in equal amount. The alkaline phosphate, free phosphoric acid, total dilution, and current strength were the same as with zinc and iron. The results obtained were in (*a*) 0.2122 gram Cd and in (*b*) 0.2120 gram Cd.

The separation of copper from the metals mentioned in connection with it was not attended by any difficulty whatever, but with cadmium compliance with the conditions mentioned was absolutely required, otherwise the results varied. In solutions containing free phosphoric acid, cadmium is unusually inclined to sponginess, so that concentration of liquid should be avoided, and the poles of the acting battery should not approach too closely to each other. The most favorable separation was found to be 1¼ inches and the proper dilution of the liquid 100–150 cc. Such, at least, was the case in the separations just described.

Copper from Cadmium.

These metals have been separated from each other in the presence of free nitric acid,[1] and also in the presence of free sulphuric acid.[2] From the results about to be given, their separation in the presence of free phosphoric acid is also possible. Two experiments were conducted under the following conditions: 0.2452 gram copper as sulphate, 0.1827 gram cadmium as sulphate, 20 cc. Na_2HPO_4 (sp. gr. 1.0358), and 10 cc. H_3PO_4 (sp. gr. = 1.347), with a total dilution of 125 cc., were exposed to the action of a current generating 0.10 cc. oxyhydrogen gas per minute for a period of twelve hours, when the following amounts of metallic copper were obtained: in (*a*) 0.2451 gram and in (*b*) 0.2452 gram. In a third experiment, with double the amount of copper present, the current was allowed to act through the night, and the deposited metal weighed 0.4904 gram. Again, with a current liberating 0.2 cc. oxyhydrogen gas per minute, conditions in all other respects similar to those previously mentioned, the found copper was 0.2451 gram. Cadmium was not detected in these deposits. The filtrates showed no trace of copper.

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[1] This Journal **2**, 42.

[2] Ibid. **12**, 110.

Silver phosphate is readily dissolved by phosphoric acid, but from such solutions even the feeblest currents deposit the metal in a spongy condition, so that it was useless in the quantitative work. But from an ammoniacal solution of the phosphate the deposition of silver metal is quite rapid and satisfactory. Two experiments gave, with a current liberating 0.20 cc. oxyhydrogen gas per minute, in (*a*) 0.1065 gram and in (*b*) 0.1061 gram Ag, the required being 0.1062 gram. Ammonia just sufficient to dissolve the phosphate is all that should be used. As I have not observed this mode of depositing silver described in the literature of electrolysis, I include it here, although it is only to the deportment of acid phosphate solutions that I wish to direct attention. The behavior of lead phosphate in alkaline solution has been recorded by me.[1] The results given are quite satisfactory. As already remarked, its phosphate being insoluble in phosphoric acid excludes experimentation in that direction.

One of the most interesting observations made in this study of acid phosphates and the electric current is that with manganese. It is well known that from nitric or sulphuric acid solution this metal is deposited as dioxide by the current. In the presence of phosphoric acid, where there is a decided excess of the latter, the deposition of dioxide upon the positive pole does not take place. This behavior has enabled me to present the following separations of copper from manganese:

1. 0.1770 gram copper as sulphate, 0.1500 gram manganese as sulphate, 30 cc. Na_2HPO_4 (sp. gr. 1.0358), 10 cc. H_3PO_4 (sp. gr. 1.347), with a total dilution of 120 cc., were exposed to the action of a current giving 1 cc. oxyhydrogen gas per minute. Copper found equaled 0.1765 gram.

2. The conditions the same as in (1), except that the current gave 1.4 cc. oxyhydrogen gas per minute. Found copper weighed 0.1770 gram. The positive pole showed no dioxide deposition. When the current exceeded that given in (1) and (2) a pink coloration was observed about the anode. This non-precipitation of the manganese is very likely due to the formation of

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[1] Proceedings Am. Phil. Soc., 1887.

the phosphate of the sesquioxide, which is only decomposed, and then but partially, by much more powerful currents than were used in this separation.

The behavior of other metallic phosphates in acid solution is receiving attention in this laboratory.

UNIV. OF PENNA., PHILA., PA., *March* 28, 1890.

A METHOD FOR THE ESTIMATION OF ALBUMEN IN URINE.

BY T. C. VAN NÜYS AND R. E. LYONS.

That albuminous bodies are completely precipitated from solution by tannic acid is proven by the investigations of Liborius,[1] Girgensohn,[2] Sebelien[3] and others. By Sebelien's method of estimating the total quantity of albuminous bodies in milk, 3 to 5 grams milk is diluted with some water, a few drops of a solution of sodium chloride or magnesium sulphate added, and the fluid is then treated with an excess of Almén's solution of tannic acid,[4] the precipitate filtered off, well washed, and the nitrogen in the precipitate estimated by Kjeldahl's method.

The weight of nitrogen is multiplied by 6.37, the product of which is the weight of albuminous bodies in the weight of the milk taken. The factor 6.37 is the number of times the per cent. (15.7) of the nitrogen in albumen is contained in 100 $\left(\frac{100}{15.7}=6.37\right)$.

Sebelien's method differs from the methods of Almén and Liborius in not depending on the fixed constitution of the compound of albumen and tannic acid, but rather all of the albumen is separated from solution, and that all nitrogen compounds not albuminous can be removed from the precipitate by washing.

Our studies of this subject were carried on with the view of ascertaining if a method of estimating albuminous bodies in urine, employing tannic acid, is practical. As urine contains nitrogenous compounds in considerable quantities, the tannic acid compound of albumen is not easily washed until pure ; besides, by continued contact of an acid, or acid salts, uric acid is precipitated, which would remain in part with the albumen ; and as the volumetric method of estimating albumen with tannic acid has not been found accurate,[1] if there remains a practical method for estimating albumen in urine with tannic acid, it is that the total quantity of nitrogen in albuminous urine is first estimated, following which estimation is made of the quantity of nitrogen in the urine having its albumen separated by means of tannic acid. The difference in the quantities of nitrogen found is the weight of nitrogen of the albumen, which, multiplied by 6.37, would give the weight of albumen. To determine if the method here outlined yields accurate results, the question arises if uric acid or other nitrogenous compounds of normal urine are retained by the precipitate formed by the tannic acid and albumen when filtered, so that the volume of urine in the undiluted filtrate would contain a smaller quantity of the normal nitrogenous constituents of the urine than is in a corresponding volume of urine before the separation of albumen.

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[1] Beitrag zu quant. Eiweissbestimmungen. Dorpat, 1871.

[2] Beiträge zur Albuminometrie. Dorpat, 1872.

[3] Studien über die analyt. Bestimmungsweise der Eiweisskörper mit besonderer Rücksicht auf die Milch.

[4] 4 grams tannic acid, 8 cc. acetic acid (1 part glacial acetic acid and 3 parts water), 190 cc. dilute alcohol, 50 per cent.

To determine this we estimated the nitrogen in normal urine before and after the introduction and removal of known quantities of albumen. We determined if Almén's solution of tannic acid produces a separation of any part of the nitrogenous compounds of normal urine, or of urine containing an abnormal quantity of the urates, and finally we employed the new method and the gravimetric method in estimating the albumen in urine and compared the results.

Pure albumen was prepared by dissolving the whites of eggs in a small quantity of water, saturating the solution with magnesium sulphate and filtering. The filtrate was then treated with dilute acetic acid until a precipitate ceased to form, filtered off, and the precipitate washed with a saturated solution of magnesium sulphate.

Having pressed the precipitate between porous paper, it was dissolved in a small quantity of water, the solution neutralised with sodium hydrate, and dialysed until nearly all of the magnesium sulphate was separated. To the turbid solution of albumen a small quantity of the oil of thyme was added to prevent bacterial decomposition, and having mixed well, the solution was filtered. In case a solution was too dilute it was concentrated by evaporation at 40° to 50° C., and when nearly free of ash, some sodium chloride was added to facilitate the precipitation with tannic acid. Solutions of ovalbumen we number 1, 2, 3, etc.

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[1] Beiträge zur Albuminometrie von Girgensohn ; Dorpat, 1872. Einige Methode zur Werthsbestimmungen der Milch von Taraszewiscz ; Dorpat, 1873.

FIRST ALBUMEN SOLUTION.

Estimation of Albumen.

(1). 10 cc. albumen solution, 10 cc. water, mixed.

(*a*). 5 cc. of the solution required by Kjeldahl's method 47.3 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the solution required by Kjeldahl's method 47.3 cc. $\frac{1}{5}$ normal KOH, corresponding to 0.1512 gram nitrogen in 100 cc. of the undiluted solution of albumen.

(2). 10 cc. albumen solution, 10 cc. Almén's solution of tannic acid, mixed and filtered without dilution.

(*a*). 5 cc. of the filtrate required by Kjeldahl's method 49.9 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required by Kjeldahl's method 49.95 cc. $\frac{1}{5}$ normal KOH, average 49.925 cc., corresponding to 0.0084 gram nitrogen of bodies not albuminous in 100 cc. of the albumen solution. The quantity of nitrogen of bodies not albuminous deducted from the total quantity of nitrogen, 0.1512 gram, leaves 0.1428 gram nitrogen of albumen, corresponding to 0.90963 gram albumen in 100 cc.

Urine.

(1). 10 cc. normal filtered urine, 10 cc. water, mixed.

(*a*). 5 cc. of the diluted urine required by Kjeldahl's method 35.8 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required by Kjeldahl's method 35.8 cc. $\frac{1}{5}$ normal KOH, corresponding to 1.5904 gram nitrogen in 100 cc. of the undiluted urine.

(2). 20 cc. urine, 10 cc. albumen solution, 10 cc. Almén's solution of tannic acid, mixed well in a small flask, and filtered without diluting.

(*a*). 5 cc. of the filtrate required by Kjeldahl's method 35.75 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required by Kjeldahl's method 35.8 cc. $\frac{1}{5}$ normal KOH, average 35.77 cc., corresponding to 1.5932 gram nitrogen in 100 cc. of the undiluted urine; but as there was 0.0084 gram nitrogen in 100 cc. of the albumen solution which was not of the albumen and therefore not precipitated by tannic acid, and the volume of No. 2, 5 cc. is $\frac{1}{4}$ albumen solution, there is $\frac{1}{4}$ of 0.0084, 0.0021 gram nitrogen of bodies not albuminous of the urine, and consequently $1.5932 - 0.0021 = 1.5911$ gram nitrogen in 100 cc. urine. Therefore there was a gain of 0.0007 gram nitrogen by the process, $1.5911 - 1.5904 = 0.0007$.

SECOND ALBUMEN SOLUTION.

Estimation of Albumen.

(1). 10 cc. albumen solution, 10 cc. water.

(*a*). 5 cc. of the diluted solution required 47.9 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted solution required 48.0 cc. $\frac{1}{5}$ normal KOH, average 47.95 cc., corresponding to 0.2296 gram nitrogen in 100 cc. of the undiluted albumen solution.

(2). 10 cc. albumen solution, 5 cc. Almén's solution, 5 cc. water, mixed well in a small flask and filtered.

(*a*). 5 cc. of the undiluted filtrate required 49.95 cc. $\frac{1}{5}$ normal KOH.

(*b*) 5 cc. of the undiluted filtrate required 49.95 cc. $\frac{1}{5}$ normal KOH, corresponding to 0.0056 gram nitrogen of bodies not albuminous in 100 cc. of the undiluted albumen solution. Deducting the latter weight from the weight of the total quantity of nitrogen ($0.2296 - 0.0056 = 0.224$), there is 0.224 gram nitrogen of the albumen in 100 cc. of the solution, which corresponds to 1.42688 gram albumen in 100 cc. ($0.224 \times 6.37 = 1.42688$).

Urine I.

(1). 10 cc. normal filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 37.3 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 37.35 cc. $\frac{1}{5}$ normal KOH, average 37.325 cc., corresponding to 1.4196 gram nitrogen in 100 cc. of the undiluted urine.

(2). 10 cc. urine, 5 cc. Almén's solution, 5 cc. water, mixed well in a small flask and filtered.

(*a*). 5 cc. of the filtrate required 37.25 cc. ⅕ normal KOH.

(*b*). 5 cc. of the filtrate required 37.3 cc. ⅕ normal KOH, average 37.275 cc., corresponding to 1.4252 gram nitrogen in 100 cc. undiluted urine.

Deducting ¼ of 0.0056 gram, the weight of nitrogen of bodies not albuminous, there remains 1.4238 gram nitrogen in 100 cc. of the undiluted urine. The results show a gain of 0.0042 gram nitrogen in 100 cc. of the undiluted urine after the separation of the albumen, 1.4238 — 1.4196 = 0.0042.

Urine II.

(1). 10 cc. normal filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 35.0 cc. ⅕ normal KOH.

(*b*). 5 cc. of the diluted urine required 34.95 cc. ⅕ normal KOH, average 34.975 cc., corresponding to 1.6828 gram nitrogen in 100 cc. of the undiluted urine.

(2). 10 cc. filtered urine, 5 cc. albumen solution, 5 cc. Almén's solution, mixed well in a small flask and filtered.

(*a*). 5 cc. of the filtrate required 34.9 cc. ⅕ normal KOH.

(*b*). 5 cc. of the filtrate required 35.0 cc. ⅕ normal KOH, average 34.95 cc., corresponding to 1.6856 gram nitrogen in 100 cc. undiluted urine; and by deducting the weight of the nitrogen of bodies not albuminous in the solution, 0.0014, there remains 1.6842 gram nitrogen in 100 cc. of the undiluted urine. By the results obtained there was found 0.0014 gram more nitrogen in 100 cc. of the undiluted urine after the separation of the albumen than there was in the same volume of undiluted urine before the addition of albumen.

THIRD ALBUMEN SOLUTION.

Estimation of Albumen.

(1). 10 cc. albumen solution, 10 cc. water.

(*a*). 5 cc. of the diluted solution required 44.4 cc. ⅕ normal KOH.

(*b*). 5 cc. of the diluted solution required 44.35 cc. ⅕ normal KOH, average 44.375 cc., corresponding to 0.63 gram nitrogen in 100 cc. of the undiluted solution.

(2). 10 cc. undiluted albumen solution, 10 cc. Almén's solution, mixed well and filtered. The filtrate was free of nitrogen.

0.63 gram nitrogen corresponds to 4.0131 grams albumen in 100 cc. of the solution.

Urine.

(1). 10 cc. filtered normal urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine, 38.7 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine, 38.8 cc. $\frac{1}{5}$ normal KOH.

(*c*). 5 cc. of the diluted urine, 38.75 cc. $\frac{1}{5}$ normal KOH, average 38.75 cc., corresponding to 1.26 gram nitrogen in 100 cc. of the undiluted urine.

(2). 10 cc. normal filtered urine, 5 cc. albumen solution, 5 cc. Almén's solution, mixed well and filtered.

(*a*). 5 cc. of the filtrate required 38.8 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 38.8 cc. $\frac{1}{5}$ normal KOH, corresponding to 1.2544 gram nitrogen in 100 cc. of the undiluted urine, or 0.0056 gram nitrogen less than in 100 cc. of the urine before the separation of albumen.

FOURTH ALBUMEN SOLUTION.

Estimation of Albumen.

(1). 10 cc. albumen solution, 10 cc. water.

(*a*). 5 cc. of the solution required 48.9 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the solution required 49.0 cc. $\frac{1}{5}$ normal KOH, average 48.95 cc., corresponding to 0.0588 gram nitrogen in 100 cc. of the undiluted solution.

(2). 10 cc. albumen solution, 10 cc. Almén's solution, mixed well and filtered.

The filtrate was free of nitrogen. 0.0588 gram nitrogen corresponds to 0.3745 gram albumen in 100 cc. of the undiluted solution.

Urine.

(1). 5 cc. normal filtered urine, 25 cc. water.

(*a*). 5 cc. of the diluted urine required 47.65 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 47.7 cc. $\frac{1}{5}$ normal KOH, average 47.675 cc., corresponding to 0.7812 gram nitrogen in 100 cc. of the undiluted urine.

(2). 5 cc. urine, 20 cc. albumen solution, 5 cc. Almén's solution, mixed and filtered.

(*a*). 5 cc. of the filtrate required 47.7 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 47.7 cc. $\frac{1}{5}$ normal KOH, corresponding to 0.7728 gram nitrogen in 100 cc. of the undiluted urine, therefore 0.0084 gram of nitrogen less than in 100 cc. of the urine before the separation of albumen.

FIFTH ALBUMEN SOLUTION.

Estimation of Albumen.

(1). 10 cc. albumen solution, 10 cc. water.

(*a*). 5 cc. of the solution required 49.55 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the solution required 49.6 cc. $\frac{1}{5}$ normal KOH, average 49.57 cc., corresponding to 0.04816 gram nitrogen in 100 cc. of the undiluted solution.

(2). 10 cc. albumen solution, 5 cc. Almén's solution, 5 cc. water, mixed and filtered.

The filtrate was free of nitrogen. 0.04816 gram nitrogen corresponds to 0.3067 gram albumen in 100 cc. of the undiluted solution.

Urine.

(1). 10 cc. normal filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 32.5 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 32.45 cc. $\frac{1}{5}$ normal KOH, average 32.47 cc., corresponding to 1.9633 gram nitrogen in 100 cc. of the undiluted urine.

(2). 15 cc. urine, 9 cc. albumen solution, 6 cc. Almén's solution, mixed and filtered.

(*a*). 5 cc. of the filtrate required 32.5 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 32.5 cc. $\frac{1}{5}$ normal KOH, corresponding to 1.96 gram nitrogen in 100 cc. undiluted urine. Therefore there was found 0.0033 gram nitrogen less in 100 cc. of the urine after the addition and removal of the albumen, $1.9633 - 1.96 = 0.0033$.

SIXTH ALBUMEN SOLUTION.

Estimation of Albumen.

(1). 10 cc. albumen solution, 10 cc. water.

(*a*). 5 cc. of the diluted solution required 48.0 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted solution required 48.05 cc. $\frac{1}{5}$ normal KOH, average 48.025 cc., corresponding to 0.2212 gram nitrogen in 100 cc. of the undiluted solution.

(2). 10 cc. albumen solution, 10 cc. Almén's solution, mixed and filtered. The filtrate was free of nitrogen.

0.2212 gram nitrogen corresponds to 1.4090 gram albumen in 100 cc. of the solution, $0.2212 \times 6.37 = 1.4090$.

Urine I.

(1). 20 cc. normal filtered urine, 20 cc. water.

(*a*). 5 cc. of the diluted urine required 38.1 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 38.05 cc. $\frac{1}{5}$ normal KOH, average 38.07 cc., corresponding to 1.3361 gram nitrogen in 100 cc. of the undiluted urine.

(2). 20 cc. urine, 10 cc. albumen solution, 10 cc. Almén's solution, mixed and filtered.

(*a*). 5 cc. of the filtrate required 38.1 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 38.15 cc. $\frac{1}{5}$ normal KOH, average 38.125 cc., corresponding to 1.33 gram nitrogen in 100 cc. of the undiluted urine. Therefore there was found 0.0061 gram nitrogen less in 100 cc. of the urine after the addition and removal of the albumen, 1.3361 — 1.33 = 0.0061.

Urine II.

(1). 20 cc. normal filtered urine, 20 cc. water.

(*a*). 5 cc. of the diluted urine required 40.45 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 40.4 cc. $\frac{1}{5}$ normal KOH, average 40.425 cc., corresponding to 1.0724 gram nitrogen in 100 cc. of the undiluted urine.

(2). 20 cc. urine, 10 cc. albumen solution, 10 cc. Almén's solution, mixed and filtered.

(*a*). 5 cc. of the filtrate required 40.4 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 40.5 cc. $\frac{1}{5}$ normal KOH, average 40.45 cc., corresponding to 1.0696 gram nitrogen in 100 cc. of the undiluted urine. Therefore there was found 0.0028 gram nitrogen less in 100 cc. of the undiluted urine after the addition and removal of the albumen, 1.0724 — 1.0696 = 0.0028.

SUMMARY OF RESULTS.

Albumen Solution.	Grams Albumen in 100 cc. of the Solution.	Total grams Nitrogen in 100 cc. of the Urine.	Dilution of the Urine.	Variation in quantity of Nitrogen in grams in 100 cc. of the Undiluted Urine before introduction of Albumen and after its removal.
I	0.9096	1.5904	1 to 2	+ 0.0007
II	1.4268	$^{\text{I}}$1.4196	1 to 2	+ 0.0042
II	1.4268	$^{\text{II}}$1.6828	1 to 2	+ 0.0014
III	4.0131	1.2600	1 to 2	— 0.0056
IV	0.3745	0.7812	1 to 6	— 0.0084
V	0.3607	1.9633	1 to 2	— 0.0033
VI	1.4090	$^{\text{I}}$1.3360	1 to 2	— 0.0061
VI	1.4090	$^{\text{II}}$1.0724	1 to 2	— 0.0028

In case the urine is diluted to a greater degree than 1 to 2, the limit of error in the estimated quantity of nitrogen increases as the quantity of nitrogen decreases by the dilution.

This is understood from the fact that with 5 cc. urine, 0.1 cc. of the $\frac{1}{5}$ normal KOH corresponds to 0.0056 gram nitrogen in 100 cc. of the urine; and if the urine be diluted from 1 to 2 or 1 to 4, 0.1 cc. $\frac{1}{5}$ normal KOH corresponds to 0.012 and 0.0224 gram nitrogen respectively. To determine if uric acid or other nitrogenous compound in normal, acid, or neutral urine, separates by contact with tannic acid, as in Almén's solution, in different periods of time, the following estimations were made.

NORMAL URINE I.

Estimation of Nitrogen.

(1). 10 cc. filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 47.25 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 47.3 cc. $\frac{1}{5}$ normal KOH, average 47.275 cc., corresponding to 0.3052 gram nitrogen in 100 cc. of the undiluted urine.

(2). 10 cc. filtered urine, 10 cc. Almén's solution, mixed well in a small flask, let stand 15 minutes and filtered.

(*a*). 5 cc. of the filtrate required 47.3 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 47.25 cc. $\frac{1}{5}$ normal KOH, average 47.275 cc., corresponding to 0.3052 gram nitrogen in 100 cc. of the undiluted urine.

(3). 10 cc. filtered urine, 10 cc. Almén's solution, mixed well in a small flask, let stand 45 minutes, and filtered.

(*a*). 5 cc. of the filtrate required 47.2 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 47.2 cc. $\frac{1}{5}$ normal KOH, corresponding to 0.3136 gram nitrogen in 100 cc. of the undiluted urine.

(4). 10 cc. filtered urine, 10 cc. Almén's solution, mixed well in a flask, let stand 60 minutes and filtered.

(*a*). 5 cc. of the filtrate required 47.25 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 47.3 cc. $\frac{1}{5}$ normal KOH, average 47.275 cc., corresponding to 0.3052 gram nitrogen in 100 cc. of the undiluted urine.

From the results of these estimations it is seen that no nitrogen compound was separated from the urine by contact with the tannic acid solution, even when the time was extended to one hour, but the urine in this case contained a minimum quantity of nitrogen, and it may be inferred that the urine contained a minimum quantity of uric acid.

NORMAL URINE II.

Urine was highly colored, acid in reaction, sp. gr. 1.031.

Estimation of Nitrogen.

(1). 10 cc. filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 31.95 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 31.9 cc. $\frac{1}{5}$ normal KOH, average 31.925 cc., corresponding to 2.0244 grams nitrogen in 100 cc. of the undiluted urine.

(2). 10 cc. urine, 10 cc. Almén's solution, mixed well in a flask, let stand 20 minutes and filtered.

(*a*). 5 cc. of the filtrate required 31.8 cc. $\frac{1}{5}$ normal KOH, corresponding to 2.0384 grams nitrogen in 100 cc. of the undiluted urine.

(3). 10 cc. urine, 10 cc. Almén's solution, mixed well in a flask, let stand 45 minutes and filtered.

(*a*). 5 cc. of the filtrate required 32.0 cc. $\frac{1}{5}$ normal KOH, corresponding to 2.016 grams nitrogen in 100 cc. of the undiluted urine.

(4). 10 cc. urine, 10 cc. Almén's solution, mixed well in a flask, let stand 60 minutes and filtered.

(*a*). 5 cc. of the filtrate required 32.1 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 32.1 cc. $\frac{1}{5}$ normal KOH, corresponding to 2.0048 grams nitrogen in 100 cc. of the undiluted urine.

The increased quantity of nitrogen found in the urine after having stood with the tannic acid 20 minutes was due either to absorption of ammonia from the air of the laboratory or to an error in the titrations, probably from the latter, as but one estimation was made.

By contact with tannic acid 45 and 60 minutes, the losses of nitrogen were 0.0084 and 0.0196 gram respectively. As 0.075 cc. of the $\frac{1}{5}$ normal KOH corresponds to 0.0084 gram nitrogen when the dilution is 1 to 2, there is no evidence that any nitrogen compound, uric acid, was separated by the contact, but that there was a loss of nitrogen by the urine remaining in contact with tannic acid 60 minutes is probable.

In order to subject urine containing an abnormal quantity of uric acid, pure urate of potassium was dissolved in normal urine, neutral in reaction; solution having taken place, the urine was filtered and the uric acid in the filtrate estimated. The quantity of uric acid in 100 cc. urine was 0.3575 gram, corresponding to about 6 grams uric acid eliminated in 24 hours.

Estimation of Nitrogen.

(1). 10 cc. of the filtered urine containing the potassium urate, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 32.2 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 32.2 cc. $\frac{1}{5}$ normal KOH, corresponding to 1.9801 gram nitrogen in 100 cc. of the undiluted urine.

(2). 10 cc. filtered urine, 10 cc. Almén's solution, mixed well in a small flask, let stand 20 minutes and filtered.

(*a*). 5 cc. of the filtrate required 32.4 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 32.45 cc. $\frac{1}{5}$ normal KOH, average 32.425 cc., corresponding to 1.9684 gram nitrogen in 100 cc. of the undiluted urine. The results of the estimations indicate the separation of 0.0117 gram nitrogen in 100 cc. of the urine by contact with the tannic acid.

Albumen was next estimated by this method, and also in the same urine by the gravimetric method.

ALBUMINOUS URINE I.

(1). 30 cc. filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 40.3 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 40.35 cc. $\frac{1}{5}$ normal KOH.

(*c*). 5 cc. of the diluted urine required 40.25 cc. $\frac{1}{5}$ normal KOH, average 40.3 cc., corresponding to 0.72426 gram nitrogen in 100 cc. undiluted urine.

(2). 30 cc. filtered urine, 10 cc. Almén's solution, mixed well and filtered.

(*a*). 5 cc. of the filtrate required 41.1 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 41.2 cc. $\frac{1}{5}$ normal KOH.

(*c*). 5 cc. of the filtrate required 41.15 cc. $\frac{1}{5}$ normal KOH, average 41.15 cc., corresponding to 0.6608 gram nitrogen in 100 cc. of the undiluted urine. The difference in the quantities of nitrogen estimated in 1 and 2 is 0.06346 gram, corresponding to 0.40424 gram albumen in 100 cc. urine.

The Gravimetric Method.

The average of three estimations of albumen in 100 cc. of the urine was 0.4399 gram, hence the difference in the results of both methods is 0.0357 gram albumen in 100 cc.

ALBUMINOUS URINE II.

(1). 10 cc. filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 40.9 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 40.9 cc. $\frac{1}{5}$ normal KOH, corresponding to 1.0192 gram nitrogen in 100 cc. of the undiluted urine.

(2). 10 cc. filtered urine, 10 cc. Almén's solution, mixed well in a flask and filtered.

(*a*). 5 cc. of the filtrate required 40.95 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 41.0 cc. $\frac{1}{5}$ normal KOH, average 40.97 cc., corresponding to 1.01136 gram nitrogen in 100 cc. of the undiluted urine. The difference in the quantities of nitrogen in 100 cc. of the urine before and after the separation of albumen is 0.00784 gram, corresponding to 0.04994 gram albumen in 100 cc. urine.

The Gravimetric Method.

The average of two estimations of albumen in 100 cc. of the urine was 0.0506 gram, hence the difference in the results of both methods is 0.0006 gram.

ALBUMINOUS URINE III.

(1). 30 cc. of the filtered urine, 20 cc. water.

(*a*). 5 cc. of the diluted urine required 34.35 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 34.3 cc. $\frac{1}{5}$ normal KOH, average 34.32 cc., corresponding to 1.4634 gram nitrogen in 100 cc. of the undiluted urine.

(2). 30 cc. filtered urine, 20 cc. Almén's solution, mixed and filtered.

(*a*). 5 cc. of the filtrate required 35.7 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 35.8 cc. $\frac{1}{5}$ normal KOH, average 35.75 cc., corresponding to 1.33 gram nitrogen in 100 cc. of the undiluted urine. The difference in the quantities of nitrogen in 100 cc. before and after the separation of albumen is 0.1334 gram, corresponding to 0.8497 gram albumen in 100 cc. of the urine.

The Gravimetric Method.

The average of three estimations of albumen by the gravimetric method was 0.8557 gram albumen in 100 cc. of the urine, hence the difference in results obtained by both methods is 0.006 gram albumen in 100 cc. of the urine.

ALBUMINOUS URINE IV.

(1). 20 cc. of the filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 35.75 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 35.85 cc. $\frac{1}{5}$ normal KOH, average 35.8 cc., corresponding to 1.1928 gram nitrogen in 100 cc. of the undiluted urine.

(2). 20 cc. filtered urine, 10 cc. Almén's solution, mixed and filtered.

(*a*). 5 cc. of the filtrate required 36.1 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 36.1 cc. $\frac{1}{5}$ normal KOH, corresponding to 1.1676 gram nitrogen in 100 cc. of the undiluted urine. The difference in the quantities of nitrogen found before and after the removal of the albumen is 0.0252 gram, corresponding to 0.1605 gram albumen in 100 cc. of the urine.

The Gravimetric Method.

The average of two estimations of albumen by the gravimetric method was 0.1551 gram albumen in 100 cc. of the urine, hence the difference in results obtained by the two methods is 0.0054 gram in 100 cc. urine.

ALBUMINOUS URINE V.

(1). 20 cc. filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 36.00 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 36.15 cc. $\frac{1}{5}$ normal KOH, average 36.1 cc., corresponding to 1.1676 gram nitrogen in 100 cc. of the undiluted urine.

(2). 20 cc. filtered urine, 3 cc. Almén's solution, 7 cc. water, mixed and filtered.

(*a*). 5 cc. of the filtrate required 38.2 cc. $\frac{1}{5}$ normal KOH, corresponding to 0.9912 gram nitrogen in 100 cc. of the undiluted urine. The difference in the quantities of nitrogen found before and after the removal of the albumen is 0.1764 gram, corresponding to 1.1236 gram albumen in 100 cc. of the undiluted urine.

The Gravimetric Method.

The average of two estimations of albumen by the gravimetric method was 1.1292 gram albumen in 100 cc. of the urine; the difference, therefore, in the results obtained by the two methods is 0.0056 gram albumen in 100 cc. urine.

ALBUMINOUS URINE VI.

(1). 20 cc. filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 40.85 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the diluted urine required 40.75 cc. $\frac{1}{5}$ normal KOH, average 40.8 cc., corresponding to 0.7728 gram nitrogen in 100 cc. of the undiluted urine.

(2). 20 cc. filtered urine, 4 cc. Almén's solution, 6 cc. water, mixed and filtered.

(*a*). 5 cc. of the filtrate required 42.9 cc. $\frac{1}{5}$ normal KOH.

(*b*). 5 cc. of the filtrate required 42.9 cc. $\frac{1}{5}$ normal KOH, corresponding to 0.5964 gram nitrogen in 100 cc. of the undiluted urine; the difference, therefore, in the quantities of nitrogen found before and after the removal of the albumen is 0.1764 gram, corresponding to 1.1236 gram albumen in 100 cc. of the undiluted urine.

The Gravimetric Method.

The average of two estimations of albumen by the gravimetric method was 1.1279 gram albumen in 100 cc. of the urine; hence the difference in the result obtained by the two methods is 0.0043 gram albumen in 100 cc. of the urine.

ALBUMINOUS URINE VII.

(1). 20 cc. filtered urine, 10 cc. water.

(*a*). 5 cc. of the diluted urine required 40.4 cc. $\frac{1}{5}$ normal KOH, corresponding to 0.8064 gram nitrogen in 100 cc. of the undiluted urine.

(2). 20 cc. filtered urine, 5 cc. Almén's solution, 5 cc. water, mixed and filtered.

(*a*). 5 cc. of the filtrate required 41.5 cc. $\frac{1}{5}$ normal KOH, corresponding to 0.714 gram nitrogen in 100 cc. of the undiluted urine.

The difference in the quantities of nitrogen found before and after removal of the albumen is 0.0924 gram, corresponding to 0.5885 gram albumen in 100 cc. of the undiluted urine.

The Gravimetric Method.

The average of two estimations of albumen by the gravimetric method was 0.5953 gram albumen in 100 cc. of the urine. The difference in the results obtained by the two methods is 0.0068 gram albumen in 100 cc. of the urine.

SUMMARY OF RESULTS.

Albuminous Urine.	Per Cent. of Albumen by New Method.	Per Cent. of Albumen by Gravimetric Method.	Difference in Results.
I,	0.4042	0.4399	0.0357
II,	0.0499	0.0506	0.0006
III,	0.8497	0.8557	0.006
IV,	0.1605	0.1551	0.0054
V,	1.1236	1.1292	0.0056
VI,	1.1236	1.1279	0.0043
VII,	0.5885	0.5953	0.0068

By the results of estimations of albumen made by the two methods the average error is 0.0092 per cent., the maximum being 0.0357 per cent., the minimum 0.0006 per cent.

The average error in 35 estimations of albumen made by Dillner,[1] employing the method of Esbach and the gravimetric method, is 0.054 per cent., the quantity of albumen in the urine being from 0.05 to 2.13 per cent.

In 73 per cent. of a great number of estimations of albumen in urine made by O. Hammarsten,[2] employing Brandberg's method and the gravimetric method, the average error is nearly 0.05 per cent.; however, in many cases the error reached 0.1 per cent.

In estimating albumen in urine by the new method a great excess of tannic acid should not be employed in separating the albumen, as it is oxidised very slowly by sulphuric acid. For ordinary quantities of albumen in urine equal volumes of Almén's solution and urine are sufficient, for small quantities one volume of Almén's solution and two volumes of urine, and in case the albumen is two per cent. the urine should be diluted with water from one to two volumes before making the estimations.

To separate the albumen, 10 cc. of the filtered urine is introduced with 10 cc. Almén's solution into a 50 cc. flask, and after mixing well the fluid is filtered through a dry filter paper into a dry beaker. 5 cc. of the filtrate is subjected to the action of 10 cc. concentrated sulphuric acid, as in the original method of Kjeldahl. Whether the dilution of the urine is 1 to 2 or 1 to 3, the albuminous urine is diluted to the same degree and 5 cc. is employed in Kjeldahl's method. To absorb the ammonia, 10 cc. normal sulphuric acid is employed. In calculating the quantity of albumen in urine from the results of the estimations, instead of subtracting the weight of nitrogen of 100 cc. of the urine proper from the weight of the total quantity of nitrogen in 100 cc. containing albumen, and multiplying the difference by 6.37 for the quantity of albumen, the process may be shortened in the following way: Subtract the number of cc. $\frac{1}{5}$ normal KOH employed in the two titrations, and multiply the difference by 0.0028, and the product of which by 40. The final product is the quantity of nitrogen in 100 cc. of the undiluted urine, which multiplied by 6.37 gives the per cent. of albumen. If the urine is diluted from 1 to 3 volumes in both cases, the weight of nitrogen is multiplied by 60, to obtain the quantity of nitrogen in 100 cc. of the undiluted urine.

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[1] Esbachs Albuminimeter. Upsala Läkareför. Förhand. **21,** 1886.

[2] Upsala Läkareförenings Förhandlingar **18,** 130.

Serum-albumen and serum-globulin, the bodies estimated by the gravimetric method, are not exactly of the same chemical constitution, and hence the employment of the factor 6.37 would not lead to correct results in all cases. The per cent. of nitrogen in serum-globulin, according to Hammarsten, is 15.85, while the per cent. of nitrogen in serum-albumen is 15.7. The factor with which to multiply the weight of nitrogen to obtain the weight of serum-globulin is 6.31 instead of 6.37. As a rule, however, serum-globulin accompanies serum-albumen in the urine in small quantities, so that the number 6.37 may be employed with comparative safety. On the other hand, for exact pathological investigations, the weight of nitrogen of albuminous bodies excreted by the kidneys affords a more certain datum than the quantity of albumen. This is apparent when the fact is taken into consideration that the per cent. of albumen in the urine, as determined by any of the methods new employed, does not represent a definite weight of nitrogen. The new method has the additional advantage of determining the total quantity of nitrogen of the normal nitrogenous constituents of the urine, which, taken into account with the weight of nitrogen of albuminous bodies, is doubtless of importance to the pathologist.

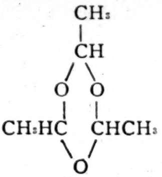
CHEMICAL LABORATORY, INDIANA UNIVERSITY, BLOOMINGTON, *March*, 1890.

PARAPROPIONIC AND METAPROPIONIC ALDEHYDES.

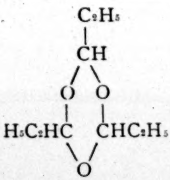
BY W. R. ORNDORFF.

(Preliminary Communication.)

When ordinary aldehyde is treated with hydrochloric acid gas at temperatures below 0°, it is converted into the solid metaldehyde and the liquid paraldehyde. This easy transformation into polymeric bodies seems to be due to the presence in the aldehyde of the carbonyl group, $\left(-\overset{|}{C}=O\right)$. The ready decomposition of the polymerides into the simple bodies when treated with various reagents, and the molecular weight, suggest that the oxygen here plays the part of connecting atoms in the molecule. Thus, when ordinary aldehyde is converted into metaldehyde or paraldehyde, the molecular weight is tripled, and the constitution of paraldehyde and metaldehyde is perhaps represented as follows :



This formula is in accord with all the facts known in regard to metaldehyde and paraldehyde, and has received experimental proof at the hands of Brühl.[1] The next higher homologue of metaldehyde and paraldehyde would have the formula



and would be likely to result from the polymerisation of propionic aldehyde, $C_2H_5.COH$. This substance would probably be more stable than paraldehyde or metaldehyde, and would perhaps yield substitution products. With this object in view, the attempt was made to prepare the parapropionic aldehyde and metapropionic aldehyde and derivatives.

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[1] Ann. Chem. (Liebig) **203**, 44.

Parapropionic Aldehyde.

Ordinary propionic aldehyde, boiling at 49°, was cooled in a freezing mixture of ice and salt, and then a few bubbles of hydrochloric acid gas were passed through it. The propionic aldehyde is thus converted very readily into parapropionic aldehyde, and, at the same time, a small quantity of metapropionic aldehyde is also formed. After allowing to stand in the freezing mixture for two or three hours, the metapropionic aldehyde is filtered off, and the parapropionic aldehyde subjected to fractional distillation. A small quantity of liquid distils over below 100°. This was found to consist of propionic aldehyde and a small quantity of parapropionic aldehyde. The larger quantity of the liquid distilled between 160–170°, and, on subjecting this fraction to further distillation, the greater part of it was found to distil at 169°–171°, with decomposition into propionic aldehyde. Under a pressure of 50 mm. it was found that it boiled at 85°–86°. Thus prepared, parapropionic aldehyde is a colorless liquid, lighter than water, having the odor of ordinary paraldehyde. It solidifies readily, if cooled down to —20° C., to a mass of crystals, resembling in every respect those formed when paraldehyde is cooled down below 0°. It is decomposed by hydrochloric and sulphuric acid, when heated with these acids, ordinary propionic aldehyde being formed, together with a small amount of tarry product.

It is not very soluble in water, and can be separated from ordinary propionic aldehyde by shaking up with water, when the propionic aldehyde dissolves.

Metapropionic Aldehyde.

Ordinary propionic aldehyde was cooled down to —20° and hydrochloric acid gas passed through it. After standing a few hours, the metaldehyde, which had separated out in colorless crystals, was filtered off, and the parapropionic aldehyde formed at the same time was decomposed by heating to the boiling point with dilute sulphuric acid, and passing the vapors through a short Hempel tube to retain the unchanged parapropionic aldehyde.

The propionic aldehyde thus regained was again subjected to the same process, and in this way ten or twelve grams of metapropionic aldehyde were made. This substance is a light crystalline solid resembling ordinary metaldehyde very closely. It is soluble in ether, chloroform and benzene, slightly soluble in alcohol and glacial acetic acid, and insoluble in water. When heated to 165° in an open tube placed in a paraffin-bath, it begins to sublime slowly, melts at 180°, but solidifies again on cooling. Above its melting point it sublimes more rapidly, collecting in the colder portion of the tube. Prof. J. F. Kemp, of the Geological Department, has kindly furnished the following particulars regarding the crystals: "The sublimed crystals are fibrous, acicular. No crystal faces show; merely rounded needles. The longer needles are aggregates of smaller ones, and are fibrous and frayed out. The needles extinguish between crossed nicols along their greatest length, and this corresponds to an axis of elasticity. At other positions they polarise brightly and are distinctly crystalline, though exhibiting no well defined faces. They are not isometric, but more probably hexagonal or tetragonal."

Heated with sulphuric acid, they are readily converted into ordinary propionic aldehyde.

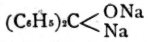
It was found impossible to make any derivatives directly either of parapropionic aldehyde or of metapropionic aldehyde. In every case the products isolated were the same as resulted from treating the propionic aldehyde itself with the various reagents. Further work on these substances was rendered impossible owing to lack of material, but it is proposed to continue the work, and, if possible, to determine the molecular weight of metapropionic aldehyde by Raoult's cryoscopic method. Further, substituted metaldehydes and paraldehydes will probably be made by starting with substituted aldehydes, and the relation existing between metaldehydes and paraldehydes in general will be investigated. It seems highly probable that if the polymerisation of the aldehydes is due to the presence in them of the carbonyl group, $(-\overset{|}{C}=O)$, polymeric ketones and polymeric acid chlorides can also be formed. For valuable assistance in the experimental part of this work I take pleasure in thanking one of my students, Mr. P. A. Mackay.

CORNELL UNIVERSITY, *May*, 1890.

Contribution from the Laboratory of General Chemistry, University of Michigan.

THE ACTION OF SODIUM ON ACETONE.

BY PAUL C. FREER.

In a recent article,[1] Beckmann describes a number of reactions between ketones and aldehydes, on the one hand, and metallic sodium on the other; among others, the action of sodium on acetophenone, by which a body  $(C_6H_5)_2C<\begin{matrix}ONa\\Na\end{matrix}$ was produced. This body was extremely unstable, benzhydrole being formed therefrom by addition of water. In the case of Beckmann's reaction there could, of course, be no doubt that one sodium atom was connected to the carbon by means of oxygen. Some time before the paper above referred to appeared, I had occasion to try the action of sodium on acetone, and, as Beckmann does not seem to have followed out this reaction, merely referring to Fittig's preparation of pinacone by the action of sodium on acetone,[2] I have resumed my investigation of the subject. If acetone be treated with metallic sodium, a reaction takes place which much resembles that of sodium upon ethyl or methyl alcohol. Fittig states that according to Löwig and Weidmann[3] no permanent gas is evolved. Apparently Fittig did not, however, attempt to isolate the body formed and study its properties, contenting himself with the preparation of pinacone. Acetone, if pure, yields a white flaky solid on addition of sodium, the whole becoming quite warm, the acetone boiling and some gas being evolved, which is combustible and apparently hydrogen. The greater part of the hydrogen, however, is not given off as such, apparently being used in the reduction of acetone to isopropyl alcohol. This point will be further investigated. After the reaction has continued for some time, a thick, cream-colored paste results, which is the desired sodium acetonate. This body, however, is extremely unstable, changing rapidly in the air, becoming dark red, giving, apparently, pinacone and some high-boiling oily products. Much better results are obtained if the metallic sodium is finely powdered and covered with a large amount of anhydrous ether, the acetone mixed with four or five times its own volume of the same medium, and then slowly added to the sodium by means of a drop-funnel, the whole operation being conducted in a stream of dry and pure hydrogen. By this means the reaction is rendered less violent, and the sodium derivative separates as a white substance. Less reduction of the acetone also takes place, for, when the operation is conducted in a flask with delivery-tube, no hydrogen being added from without, a considerable quantity of a gas, insoluble in water and alcohol, and combustible, apparently hydrogen, is obtained. When all of the metallic sodium has disappeared, the resulting insoluble body is quickly filtered, and, after being spread on a porous plate, is freed from ether over solid paraffin in a vacuum. This part of the operation must be conducted with the greatest celerity, as the body is instantly turned pink by exposure to the atmosphere. Even when the whole takes but one or two minutes, the sodium determinations always show an excess of sodium over that calculated for $CH_3-CONa-CH_2$.

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[1] Ber. d. chem. Gesell. **22**, 912.

[2] Ann. Chem. (Liebig) **110**, 25; **114**, 54.

[3] J. prakt. Chem. **21**, 54.

I. .4760 gram substance gave .4434 gram Na_2SO_4.

II. .5525 gram substance gave .5547 gram Na_2SO_4.

	Calculated.	Found.	
		I.	II.
Na	28.75 per cent.	30.17	32.63

The results of these analyses prove, at least, that there is one atom of sodium to one of acetone, thus bringing the body in line with acetoacetic ether, for, presumably, the reaction which takes place is the replacement of one atom of hydrogen by one of sodium. The sodium compound on being added to dilute hydrochloric acid regenerates acetone, which was detected in the liquid by means of the iodoform test and by the formation of the soluble compound of acetone with the precipitated oxide of mercury. If the sodium compound be exposed to the air for some time and then added to dilute hydrochloric acid, an oil is also formed which probably corresponds to some of the bodies obtained by Fittig.[1]

In order further to prove the composition of the body, an attempt was made to convert it into acetoacetic ether by the addition of chlorocarbonic ether. If this latter substance be added to the sodium derivative suspended in ether, a reaction at once takes place, sodium chloride is formed, and, on the addition of water, drying of the ethereal solution, and evaporation of the ether, an oil remains which on fractional distillation seems to be composed of several bodies. The greater portion, however, boiling between 185°–200°, was not identical with acetoacetic ether. What these bodies are I am not at present able to state, but I should like to reserve for myself the future investigation of this interesting subject. I should like to return thanks to Mr. G. O. Higley, who has assisted me in the work.

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[1] Ann. Chem. (Liebig) **110**, 25.

April, 1890.

REVIEWS AND REPORTS.

Recent Synthetical Experiments in the Sugar Series.

Professor Emil Fischer's researches on the sugars of the glucose group have been remarkably successful, and recently he has effected the synthesis of both dextrose and levulose. A year ago, in this journal,[1] the experiments were described by means of which he had succeeded in preparing a new synthetical sugar, which he called acrose, and which was found to be an isomer of dextrose and levulose. Acrose possesses all the general properties of dextrose and levulose, and only differs from these natural sugars in being optically inactive. Fischer has now succeeded in determining the constitution of acrose, and in his recent papers[2] he has shown that it is the inactive modification of levulose. It bears the same relation to ordinary levulose that racemic acid bears to ordinary tartaric acid; and just as racemic acid can be split into dextro- and levo-tartaric acids, so from acrose ordinary levulose and a new levulose having an equal but opposite rotatory power, can be obtained.

The obstacles that are encountered in this kind of work are very great, and one can gain some idea of the difficulty of determining the constitution of a sugar by remembering that, according to the Le Bel-Van't Hoff hypothesis,[3] a compound with four asymmetric carbon atoms like dextrose can exist in sixteen stereometric forms. Nevertheless Fischer has not only determined the constitution of acrose and effected the synthesis of levulose, but he has also discovered the inactive and the levo-modifications of mannite and of the new sugar mannose. He has shown that mannose and dextrose have the same constitution and that one may be converted into the other. He has further prepared all these substances synthetically, and, what is also of very great importance, he has developed and perfected the methods of transforming the sugars and their derivatives into one another to such an extent that the synthesis of the remaining members of the glucose group will probably be effected in the near future. In fact, so great are the additions to our knowledge resulting from these researches that Fischer's work may well be said to mark the beginning of a new epoch in the history of the carbohydrates.

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[1] This Journal **11**, 277.

[2] Ber. d. chem. Ges. **23**, 372, 376.

[3] Van't Hoff. Dix années dans l'histoire d'une théorie, p. 54.

Mannose.

This new sugar was discovered by Fischer[1] in studying the oxidation products of the poly-acid alcohols with the aid of phenylhydrazine. It is obtained, together with levulose, by the oxidation of mannite with nitric acid, and it can readily be distinguished from the other sugars on account of the insolubility of its hydrazone. Mannose has the composition represented by the formula $C_6H_{12}O_6$, and is therefore isomeric with dextrose and levulose, and, like these, it reduces Fehling's solution, and undergoes fermentation when mixed with yeast. It is optically active, and turns the plane of polarised light to the right, but not so strongly as dextrose. Its specific rotatory power is $+12.96$, that of dextrose being $+58.7$. Reduction with sodium amalgam converts it into mannite. Mannose has not yet been obtained in crystalline condition. The white solid sugar deliquesces rapidly in moist air, and is extremely easily soluble in water. It dissolves with difficulty in absolute alcohol, and is insoluble in absolute ether. Like dextrose and levulose, mannose can be converted into furfurol and levulinic acid. Treatment with bromine water converts it into mannonic acid, an isomer of gluconic acid.

But the distinguishing characteristic of mannose is its behavior with phenylhydrazine. The cold aqueous solution of the sugar, when treated with phenylhydrazine, gives at once a crystalline precipitate of mannose phenylhydrazone, whereas the hydrazones of dextrose and levulose and the other sugars are readily soluble in water. When heated with more phenylhydrazine, the mannose hydrazone is converted into an osazone, which is identical in all its properties with phenylglucosazone, the compound that is obtained from dextrose and levulose under similar circumstances. As glucosazone can be converted into levulose, it is therefore possible by this means to transform mannose into levulose.

Constitution of Mannose.[2]—As mannose differs in properties from both dextrose and levulose, it was at first supposed that its constitution was different from that of either of these sugars. Thus the formula of dextrose being

$$CH_2OH.\,CHOH.\,CHOH.\,CHOH.\,CHOH.\,CHO,$$

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[1] Ber. d. chem. Ges. **21**, 1805; **22**, 365.

[2] Ibid. **22**, 365.

and that of levulose

$$CH_2OH.\,CHOH.\,CHOH.\,CHOH.\,CO.CH_2OH,$$

the formula $CH_2OH.\,CHOH.\,CHOH.\,CO.CHOH.\,CH_2OH$ suggested itself for mannose. In order to obtain experimental evidence either for or against this formula, mannose was treated with hydrocyanic acid, according to Kiliani's[1] method of determining the constitution of sugars. Direct addition took place, and from the resulting compound mannose-carbonic acid was obtained. This acid, upon reduction with hydriodic acid, was converted into normal heptoic acid. This result indicates that the constitution of mannose cannot be represented by the formula given above, because a sugar whose constitution is represented by that formula would by this process have been converted into an isoheptoic acid. But the fact that normal heptoic acid was obtained indicates that mannose contains an aldehyde group, and that its constitution must be expressed by the same formula as that which represents the constitution of dextrose. Mannose and dextrose are, therefore, physical isomers. To explain this isomerism recourse must be had to the Le Bel-Van't Hoff hypothesis, according to which it is possible to foresee the existence of eight optically active and eight inactive compounds of the formula of dextrose. Both compounds are dextro-rotatory, but as one of them turns the plane of polarised light to a much greater extent than the other, Fischer at first supposed that dextrose and mannose were optical isomers, that they were the dextro and levo-modifications of the same structural system, and that the rule which usually holds in such cases, namely, that the one isomer turns as far to the left as the other to the right, was modified in this case in some unknown manner by the remaining asymmetric carbon atoms. This supposition was not confirmed by subsequent experiments, for, as will be shown below, another mannose similar in all its properties to the one here described, but possessing an equal but opposite rotatory power, was obtained from arabinose carbonic acid.

Reduction of the Acids of the Sugars.[2]

Before proceeding to describe how the optical isomer of mannose was obtained, it is necessary to call attention to a reaction which is of some importance, and which is a general one for the acids of the sugar series. Ordinarily the carboxyl group of organic acids cannot be reduced to the aldehyde group by means of nascent hydrogen. This reduction, however, takes place readily, as has been discovered by Fischer, in the case of the sugar acids that yield lactones. If gluconic acid lactone, for example, be treated with sodium amalgam, and the solution be acidified from time to time, it soon acquires the power of reducing Fehling's solution, and by continued action a solution of sugar is obtained. The solution contains dextrose, and when it is treated with phenylhydrazine it gives glucosazone. In the same way mannonic acid, obtained by the oxidation of mannose with bromine water, was reduced with sodium amalgam and mannose again obtained. Other sugar acids behaved in the same way—in short, the method appears to be a general one, and one of very great importance in connection with the synthesis of the sugars. It is possible by means of this method, together with Kiliani's reaction, to build up a sugar from one containing a smaller number of carbon atoms. For, by treating a sugar with hydrocyanic acid, an addition product is obtained from which an acid containing one carbon atom more than the original sugar can be prepared. This acid can then be reduced with sodium amalgam, and thus converted into the corresponding sugar. The process of lengthening the chain of carbon atoms can then be repeated. Thus far only acids that form lactones have been reduced with sodium amalgam, and it appears that this property is in some way connected with the power of forming lactones.

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[1] Ber. d. chem. Ges. **21**, 916.

[2] Ibid. **22**, 2204.

Synthesis of Mannose and Levulose.[1]

When mannose is oxidised with bromine water it is converted into mannonic acid. A thorough examination of the properties of mannonic acid showed that it has almost identically the same properties as arabinose-carbonic acid. The latter compound was discovered by Kiliani,[2] and is obtained from the addition product which is formed by the union of hydrocyanic acid and arabinose. The lactones of these acids are so similar in properties that they would be regarded as identical were it not for the fact that they rotate the plane of polarised light in opposite directions. As their rotatory power is very nearly equal but in opposite directions, it seemed very probable that they were optical isomers. This supposition proved to be true, for, on mixing solutions of equal weights of the two lactones, an optically inactive compound of the same composition was obtained. This inactive lactone can be transformed into inactive salts and other derivatives, and it is only possible by certain special methods, to be described below, to again resolve it into its optically active constituents. The three lactones can by reduction be converted into sugars, and these in turn into three hexacid alcohols, and the corresponding members of these three series of reduction products bear the same relation to each other as do the original lactones. Thus, from the lactone of mannonic acid, mannose and ordinary mannite are obtained, while from the lactone of arabinose-carbonic acid, a levo-mannose and a levo-mannite are obtained; and finally, reduction of the inactive lactone gives two corresponding inactive derivatives. The relation of these compounds is shown by the following table:

[1] Ber. d. chem. Ges. **23**, 370.

[2] Ibid. **19**, 3034.

d-SERIES.	*i*-SERIES.	*l*-SERIES.
d-Mannonic acid lactone (dextro-rotatory).	*i*-Mannonic acid lactone.	*l*-Arabinose-carbonic acid lactone (levo-rotatory).
d-Mannonic acid.	*i*-Mannonic acid.	*l*-Arabinose-carbonic acid.
d-Mannose (ordinary) (dextro-rotatory).	*i*-Mannose.	*l*-Mannose (levo-rotatory).
d-Mannite (dextro-rotatory).	*i*-Mannite (*a*-acrite).	*l*-Mannite (levo-rotatory).
d-Mannose phenylhydrazone (levo-rotatory).	*i*-Mannose phenylhydrazone.	*l*-Mannose hydrazone (dextro-rotatory).
d-Phenylglucosazone (levo-rotatory).	*i*-Phenylglucosazone (*a*-acrosazone).	*l*-Phenylglucosazone (dextro-rotatory).

To avoid confusion, the compounds of the three series are designated by prefixing the letters *d*, *i* and *l* to their names according to the rotatory power of the sugar of the series. The letter *d* or *l* before the name of a compound does not necessarily imply that the compound is either dextro- or levo-rotatory, but merely that it is a derivative of a dextro- or levo-rotatory sugar. Thus the two phenylhydrazine derivatives of *d*-mannose are levo-rotatory.

In a recent paper[1] the preparation and properties of the new sugars *l*-mannose and *i*-mannose and their derivatives are described. Both of them, like *d*-mannose, are stereometric isomers of dextrose. *l*-Mannose can only be fermented with great difficulty, and, like *d*-mannose, it is characterised by the insolubility of its hydrazone. *l*-Phenylglucosazone is the optical isomer of ordinary or *d*-phenylglucosazone, and *l*-mannite of ordinary *d*-mannite.

That *i*-mannonic acid is really the optically inactive modification of *d*- and *l*-mannonic acid was shown by splitting it up into its two active components. Two methods were used for this purpose; the first one consisted in subjecting it to fermentation with penicillium glaucum. The *d*-mannonic acid was consumed by the ferment, while the *l*-acid remained behind and was isolated. The second method depended upon the unequal solubility of the strychnine salts of the two acids in absolute alcohol; the salt of the *d*-mannonic acid being much more soluble than the *l* variety, can be readily separated from the latter. A separation of the optically active constituents of *i*-mannose was brought about by fermentation with yeast. When yeast acts upon *i*-mannose, the *d*-mannose is rapidly consumed and the *l*-mannose remains behind.

Perhaps the most important and interesting discovery[2] made in the course of this admirable investigation was the observation that *i*-mannite and *α*-acrite are identical substances. *α*-Acrite, it will be remembered, is the hexacid alcohol obtained by the reduction of acrose, the new synthetical sugar which had been built up from glycerin, acroleïn bromide and from formic aldehyde. *α*-Acrite has identically the same properties that *i*-mannite has, and, like the latter compound, it can be converted into *i*-mannose. *α*-Acrosazone also is identical with *i*-phenylglucosazone. As, therefore, acrose and *i*-mannose give the same osazone with phenylhydrazine, it follows that the constitution of acrose must be represented by one of the two formulas:

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[1] Ber. d. chem. Ges. **23**, 373.

[2] Ibid. **23**, 383.

$$CH_2OH.CHOH.CHOH.CHOH.CHOH.CHO$$

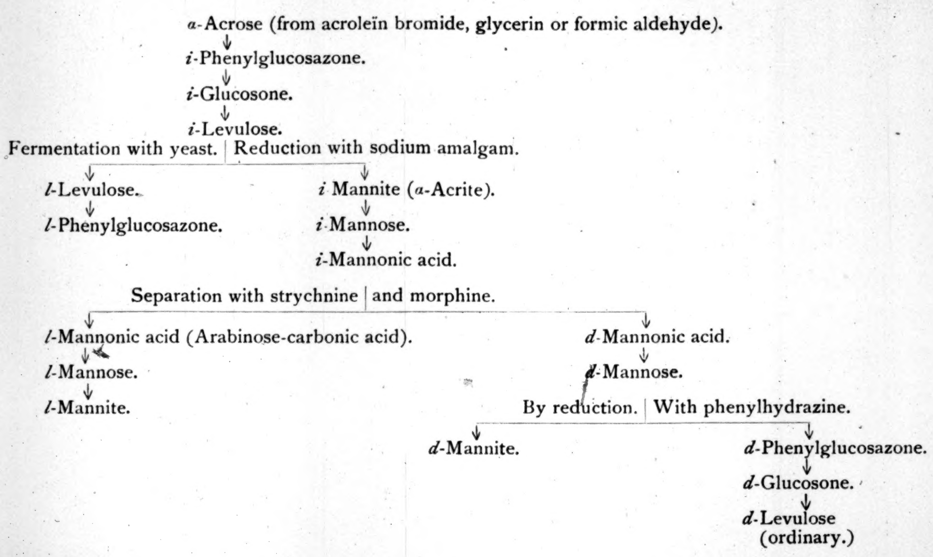
i-Mannose.

and $$CH_2OH.CHOH.CHOH.CHOH.CO.CH_2OH.$$

i-Levulose.

If acrose has the constitution represented by the first one, then it is identical with *i*-mannose, and, like the latter substance, it ought to give a difficultly soluble hydrazone when its solution is treated with phenylhydrazine. Acrose was, therefore, prepared by direct synthesis from acroleïn bromide, and its solution was tested with phenylhydrazine. Under no circumstances could the formation of an insoluble hydrazone be observed. This result, therefore, leads to the conclusion that acrose is *i*-levulose, and its constitution must be represented by the second formula.' The synthetical sugar obtained from *α*-acrosazone was also examined in the same way, and, as was to be expected, it also proved to be *i*-levulose.

Further evidence in favor of the view that acrose is *i*-levulose was obtained by observing the changes which it undergoes upon fermentation. When acrose was mixed with yeast, it was found that one of the optical components, *d*-levulose, was consumed much more rapidly than the other, and after the fermentation had continued for some time, the *l*-levulose was recognised and separated from the solution by means of its osazone. So also the *α*-acrite, like *i*-mannite, was converted into *i*-mannose and *i*-mannonic acid. But the latter compound can be separated into its optically active constituents, and these in turn can be transformed, on the one hand, into *l*-mannose and *l*-mannite, and on the other hand into ordinary mannose and mannite, and into levulose. Thus the complete synthesis of levulose and of the three series of mannite derivatives has been effected. The successive steps in the synthesis are indicated in the following table.


a-Acrose (from acroleïn bromide, glycerin or formic aldehyde).
i-Phenylglucosazone.
i-Glucosone.
i-Levulose.
Fermentation with yeast.
Reduction with sodium amalgam.
l-Levulose.
l-Phenylglucosazone.
i Mannite (a-Acrite).
i Mannose.
i-Mannonic acid.
Separation with strychnine
and morphine.
l-Mannonic acid (Arabinose-carbonic acid).
l-Mannose.
l-Mannite.
d-Mannonic acid.
d-Mannose.
By reduction.
With phenylhydrazine.
d-Mannite.
d-Phenylglucosazone.
d-Glucosone.
d-Levulose
(ordinary.)

Synthesis of Dextrose.

As has been shown above, *d*-mannose and dextrose have the same constitution and must be regarded as stereometric isomers. Both sugars give the same osazone when treated with phenylhydrazine. It follows, therefore, that the difference between them is due to the asymmetry of the carbon atom as_1 in the formula:

$$\mathrm{CHO.}\underset{as_1}{\mathrm{C}}\mathrm{HOH.CHOH.CHOH.CHOH.CH_2OH.}$$

Fischer also regarded it as highly probable that in mannose the carbon atom as_1 was optically inactive, and that it plays a rôle similar to that of the two carbon atoms in racemic acid. If this supposition is true, then mannonic acid would be related to gluconic acid in the same way that racemic acid is related to one of the active tartaric acids, or this relationship would be analogous to that of racemic acid to mesotartaric acid. In his last paper[1] Fischer shows that the latter is the true relation. Each of these acids can be transformed into the other. When either one is heated with quinoline to a temperature of 140°, a mixture of the two acids is obtained. This transformation is analogous to that which has been observed in the case of racemic and mesotartaric acids. When either one of these is heated with water to a temperature of 170°–180°, a mixture of both is obtained.

For the purpose of preparing dextrose, mannonic acid was heated with quinoline, and from the mixture of acids thus obtained the gluconic acid was separated by means of its brucine salt. The brucine salt was decomposed, and the gluconic acid was found to be identical in properties with the gluconic acid obtained by the oxidation of dextrose. The acid was thereupon reduced with sodium amalgam, and from the liquid, *anhydrous crystalline dextrose*, identical in all its properties with ordinary dextrose, was obtained.

The synthesis of dextrose, therefore, is achieved, for, as will be seen in the table printed above, *d*-mannonic acid has been prepared from acrose, and acrose has been made from formic aldehyde.

E. H. Keiser.

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[1] Ber. d. chem. Ges. **23**, 799.